**POWER**

*A McGraw-Hill Publication—Established 1884*

PHILIP W. SWAIN, *Editor*

# HORIZONS and BRASS TACKS

THIS number of *Power,* unusual in content, invites comment. In it you will find five plant articles of extraordinary interest and nine practical articles on piping. Horizons plus brass tacks!

● First the horizons: Those engineers who look ahead, if only for the next fourteen pages of this number, will see that at least three of America's leading industrials are getting ready, or are now ready, to generate more power at lower cost. They will see and respect the names of Ford, Firestone, West Virginia Pulp & Paper, long associated with progressive management, and now with expanding modernized high-pressure steam plants.

● They will list these leaders among those who refuse to burden their manufacturing costs and net profits with any share of America's annual three-quarter-billion-dollar waste in the generation and application of industrial power.

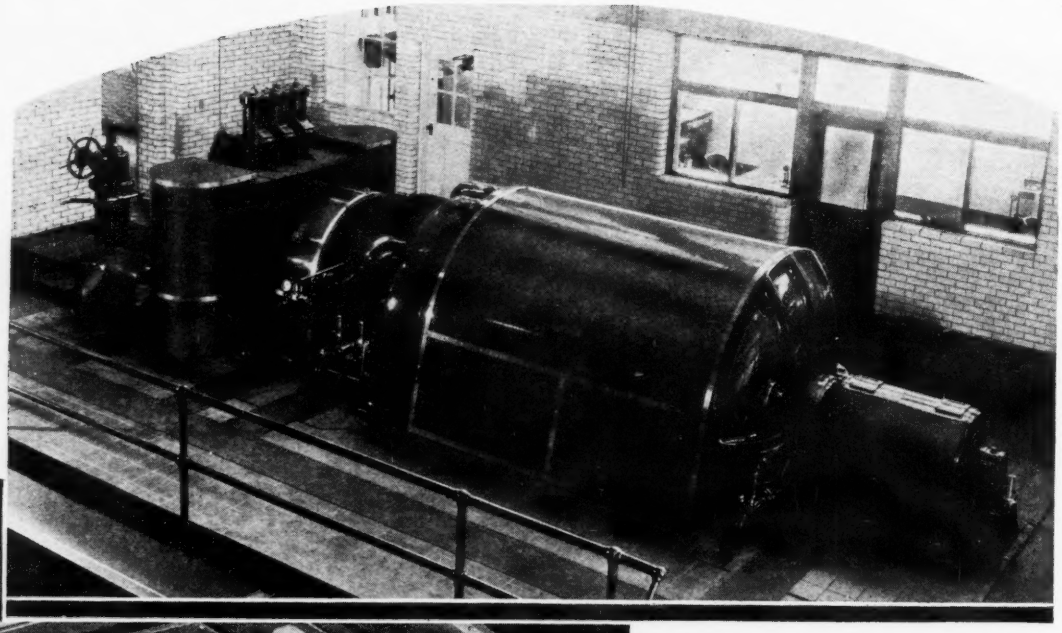
● In the utility field they will see that Detroit Edison, long noted for level-headed progressiveness, has completely modernized its great Connors Creek station.

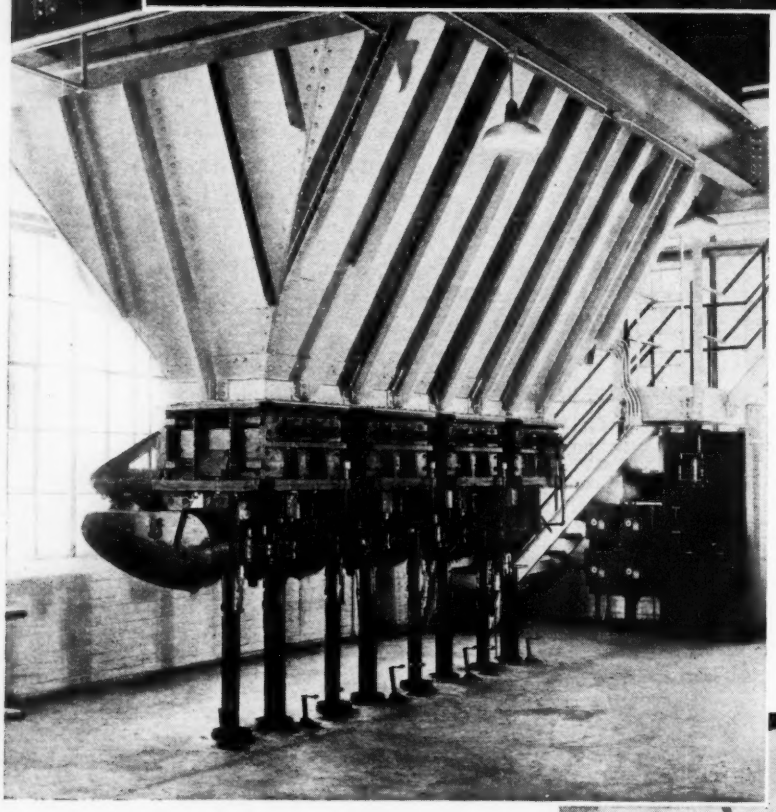
● In probably the first story of its operation to be published anywhere, they will learn how Copenhagen, Denmark, has harnessed the world's largest diesel engine to a great steam plant for an economy not possible there with either steam or diesel alone.

● Here then are the first real engineering stories on five great power events of today—new horizons, sign posts to the immediate economic future of power generation. These are essential background information for every power engineer, in every kind of plant, large or small.

● But how about the every-day job of the average power engineer? How about brass-tack practical information that can be immediately applied in small and medium-sized plants and by those whose interests spread out from steam to all the power services? Plenty!

● Practical articles on heating and air conditioning, and with them a real piping handbook in 13 pages, the boiled-down fundamentals—9 articles covering each phase from layout right on through to maintenance. All these are based on first-hand information from the source. from those who are doing today's best practical work in the field of power piping. This section is written to be *used* by the men who have to make things run.





# FIRESTONE

*By William K. Adkins*

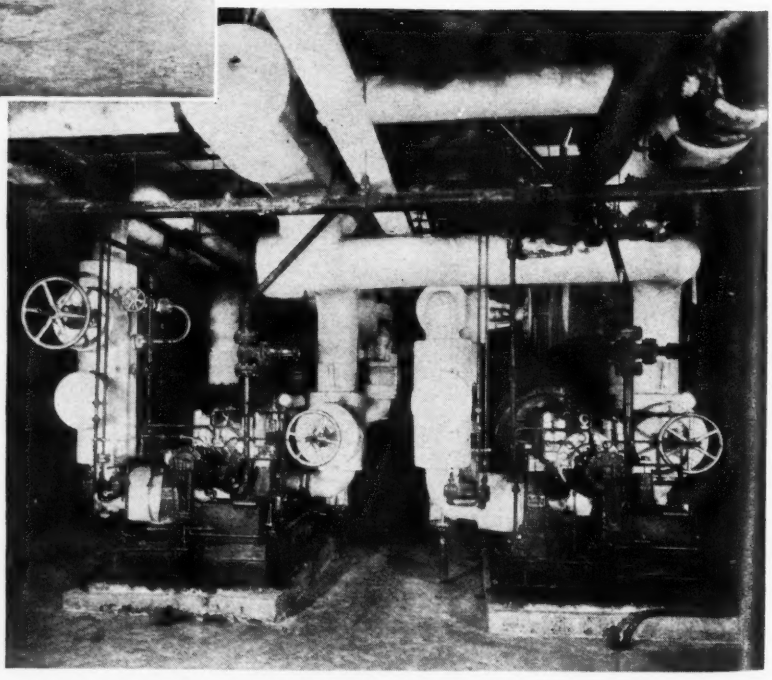
*Power Engineer, Firestone Tire & Rubber Co.*

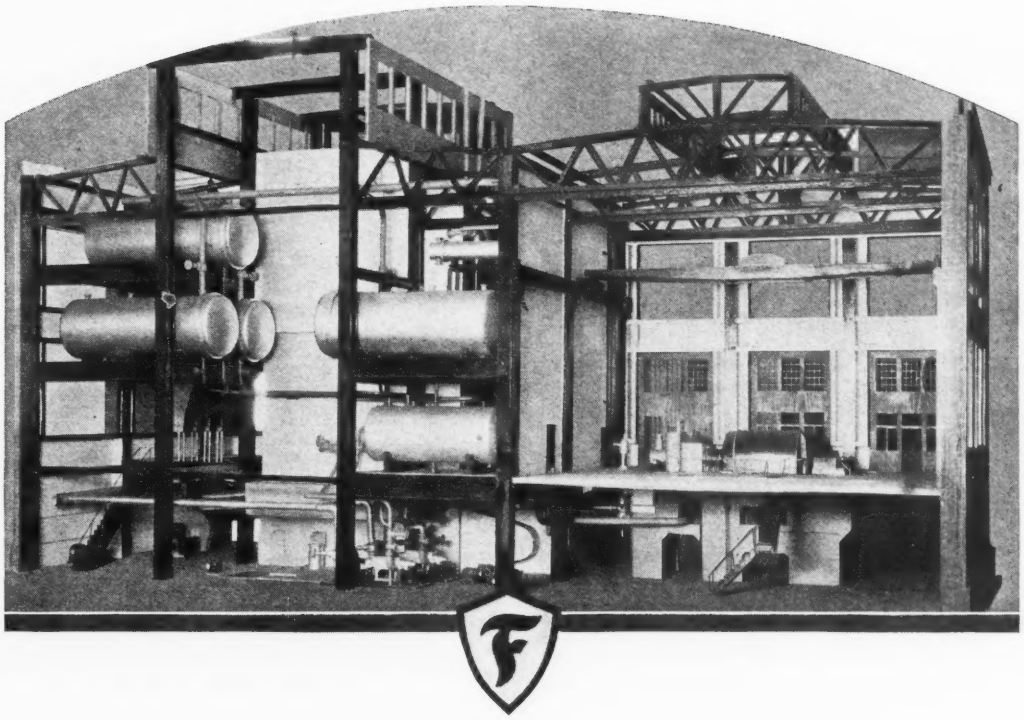
**300,000-lb.-per-hr. high-pressure boiler and 10,000-kw. turbine exhausting to process-steam evaporators installed**

**Top—New 10,000-kw. turbine-generator exhausting to process-steam evaporators**

**Above—The bunker for the 300,000-lb. per hr. boiler**

**Right—Boiler feed pumps**





# GOES TO 1,400 LB. AT AKRON

FIRESTONE Tire & Rubber Company, Akron, Ohio, is soon to put into operation a 1,400-lb. boiler and a 10,000-kw. back-pressure turbine exhausting to evaporators supplying process steam. We needed more power, and chose to produce it by installing new equipment (rather than rehabilitating the old) because it returned more on our investment and because of the age and condition of the units we had. Of total steam produced for Firestone's Akron plants, about half was used for process and half for power generation and auxiliaries with the condensing plant. Here was an ideal set-up for a back-pressure turbine, and our studies showed 1,400-lb. boiler pressure as best for our particular needs.

The boiler, a cross-drum, sectional-header type, incorporates a number of features. To X-ray the welds in the 4-in. thick main drum, largest ever produced by fusion welding, a new technique had to be developed, for the first X-ray pictures were only blanks. An apparatus called the "Bucky" gave the answer, perfect pictures, even though exposure time was still two hours per picture. A specially designed furnace also had to be built for stress-relieving.

Instead of the usual single drum for boilers of this type, two were used, the additional lower drum increasing reserve water storage from 1.34 min. to 2.7 min. at full-load operation. The furnace is completely surrounded by water walls backed with 2½ to 3 in. of insulating brick, then 3 in. of rock wool, inside the 10-gage steel casing. For each water wall there are two top headers, one above the other, into which alternate tubes are rolled. The top headers for the side walls are supported by steel beams, independent of the rest of the boiler and the lower headers are hung on the water-wall tubes. This permits free downward expansion of the side walls. All four walls and furnace bottom are fed from a separate header at the bottom of the furnace and supplied by downcomers connected to the rear boiler headers.

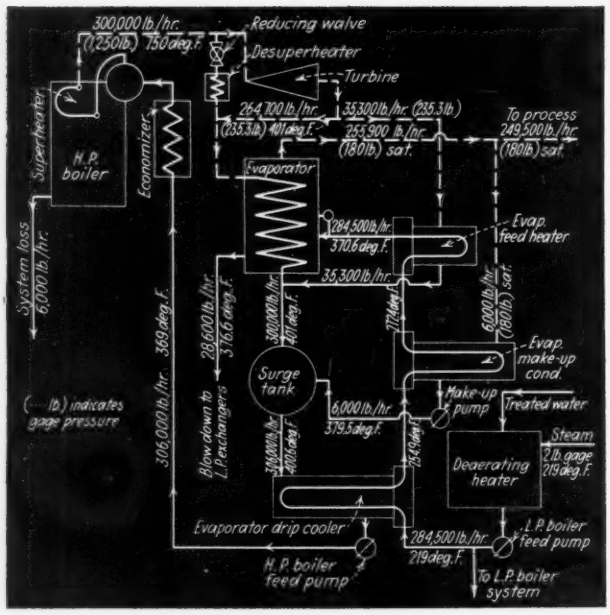
The 8,110-sq.ft. economizer is of integral-loop construction with horizontal tubes. Gas passage is downward through the economizer, water flow upward through the tubes to the main drum, entering at two points. From the points of entry, the water is distributed along the full length of the drum so that it flows over steam-washing screens. Water enters the economizer at 380 deg. and leaves at 472 deg., cooling the gas from 1,020 deg. to 680.

Built of 12-gage copperoid vertical steel plates (electrically welded and arranged for counterflow), the 23,100-sq.ft. (total plate area) air preheater lowers gas temperature from 680 to 410 deg. and heats 100-deg. air to 440 deg.

Induced-draft fan (183,000 c.f.m.), forced-draft fan (103,000 c.f.m.) and primary air fan (21,000 c.f.m.) are driven by constant-speed motors and have damper regulation. Since the unit is designed for base-load operation, we expect the constant-speed drives to be entirely satisfactory.

A cowl was installed at the point where the uptake from the induced-draft fan enters the breeching. This will make it possible to operate the boiler in conjunction with natural-draft boilers served by the same stack.

Powdered coal is supplied to the new boiler from




**Heat balance for initial operation of the high-pressure boiler**

the 10-year-old preparation plant. Duplex feeders take their supply from a 90-ton pulverized-coal bunker and feed the coal into the four corners of the square furnace near the bottom. Each corner has two feed supply lines, one to each burner, through which primary air at 444 deg. delivers the coal. Secondary air enters the furnace around the burners and at the same temperature as the primary air, since both are supplied from the forced-draft fan through the air heater.

The furnace bottom is of fin-tube construction and mounted on beams strong enough to carry the slag load. A refractory was applied to fill the small openings for initial operation, but in regular operation the fin tubes will chill the slag so that it forms its own seal. Slag-handling equipment passes the slag through the disintegrating chamber to the dewatering tank.

Steam is supplied to the non-condensing turbine at 1,250 lb. and 750 deg. F., and exhausts to the evaporator at 235 lb. and 21 deg. superheat. A back-pressure governor with an operating range of 220 to 265 lb., makes it possible to increase turbine output by reducing back pressure or to increase process steam generated in the evaporators by increasing back pressure.

When supplied with 300,000 lb. of steam per hr. under these conditions, the turbine-generator will produce 10,870 kw. The generator is designed for 80 per cent p.f., 3 phase, 60 cycles, 11,000 volts, 3,600 r.p.m., with direct-connected exciter. Steam rate at 10,000 kw. is 28 lb., or 3,761 B.t.u. per kw.-hr.

Both the main generator and the exciter are totally enclosed and are served by the twin air cooler designed to operate on 85-deg. water. To safeguard the turbine from oil fires, oil lines near high temperatures are enclosed in larger lines which conduct any leakage in the hot zone away from the danger point.

A reducing and desuperheating station is installed in a by-pass line around the turbine, so that the boiler can deliver full steam capacity to evaporators for distribution to the factory, if the turbine is out of service.

Five evaporators, when operating in parallel and supplied with 269,000 lb. of dry saturated steam per hr. at 235 lb. gage, will produce continuously 260,900 lb. per hr. of vapor at 180 lb. gage from 375-deg. feedwater. This performance is based on feedwater containing not more than 22 gr. per U. S. gal. total im-

## PRINCIPAL EQUIPMENT IN POWER PLANT
### Firestone Tire & Rubber Company

Boiler, inclined-straight-tube, cross-drum, sectional-header; heating surface, sq.ft.: boiler 11,793 front and rear walls, 1,697 each, side walls 3,664 total, bottom 526. Normal steaming capacity, lb. per hr. 300,000; gage pressure 1,400 lb. per sq.in., total temperature 760 deg. F. Steam drum, 54 in. dia., 23 ft. long, 4 in. thick, has steam washer. Aux. water-storage drum 36 in. dia., 23 ft. long, 2 1/16 in. shell. Drums Class 1 welded. Furnace, volume 14,500 cu.ft., flat-bottom slagtap; heat release per hour at full load, per cu.ft. of furnace volume, 24,190 B.t.u. ..... Combustion Engineering Co.
Superheater, Elesco, single-pass, multiple-loop, inter-deck, 1 1/4-in. O.D. seamless tubes; heating surface 4,000 sq.ft. ..... Superheater Co.
Economizer, integral-loop, 2-in. O.D. fin tubes; heating surface, 8,110 sq.ft. ..... Combustion Engineering Co.
Air heater, vertical-plate; plate area 23,100 sq.ft., Combustion Engineering Co.
Pulverized-coal burners, four, 6-in. duplex Lopulco, tangential type, pulverized-coal feeders driven by adjustable-speed motors ... Combustion Engineering Co.
Duct work and boiler heat insulation, Combustion Engineering Co.
Structural steel ..... Burger Iron Co.
Ash disposal, Hydrojet ..... Allen-Sherman-Hoff Co.
Piping ..... Grinnell Co.
Automatic combustion control ..... Hagan Corp.
Heat insulation for piping, heat exchanger and evap., Keasbey & Mattison Co.
Safety valves ..... Crosby Steam Gage & Valve Co.
Blowoff valves ..... Cochrane Corp.
Non-return valves ..... Wm. Powell Co.
Stop and check valves in feed lines. Edwards Valve & Mfg. Co.
High and medium pressure valves ..... Wm. Powell Co.
Reducing valves and desuperheater ..... Swartwout Co.
Feedwater regulator ..... Swartwout Co.
Excess-pressure regulator ..... Swartwout Co.
Soot blowers ..... Diamond Power Specialty Co.
Water columns ..... Diamond Power Specialty Co.
Boiler meter ..... Bailey Meter Co.
Boiler-water-level recorder ..... Bailey Meter Co.
Pressure and temperature recorder ..... Bailey Meter Co.
Draft gages ..... Bailey Meter Co.
Flue-gas temperature recorder ..... Leeds & Northrup
Indicating pressure gages .. Consolidated-Ashcroft-Hancock Co., Crosby Steam Gage & Valve Co.
Evaporators: 5 single-effect coil-type, effec. surf. 4,320 sq.ft., each; coil press. 235 lb.; shell press. 190 lb.; makes process steam with turbine exhaust. Capacity (each) 52,200 lb. per hr., 190 lb. press., Foster Wheeler Corp.
Evaporator feedwater heater, capacity 289,500 lb. per hr. from 291 to 375 deg. F. ..... Foster Wheeler Corp.
Evaporator-drip cooler, capacity 310,000 lb. per hr. from 400 to 370 deg. F. ..... Foster Wheeler Corp.
Makeup condenser; capacity 10,000 lb. per hr. Foster Wheeler Corp.
Surge tank ..... Hedges Walsh Weidner Co.
Distilled-water tank ..... Biggs Boiler Works Co.
Deaerating heater, 400,000 lb. per hr. ..... Elliott Co.
Make-up pumps, two single-stage, 50-g.p.m., 380 deg. F. head 845 ft. ..... Ingersoll-Rand Co.
Driven by 20-hp. Allis-Chalmers motors
Boiler-feed pumps, two, 7-stage, 850-g.p.m., 370 deg. F., head 3,604 ft., 8,550 r.p.m. ..... Ingersoll-Rand Co.
Driven by 1,000-hp. steam turbines. Terry Steam Turbine Co.
Feed-pump governors ..... Swartwout Co.
Primary-air fan, 21,000 c.f.m. at 440 deg. F., 15 in. water, 1,160 r.p.m., 100 hp. ..... Buffalo Forge Co.
Forced-draft fan, 103,000 c.f.m. at 100 deg. F., 10 in. water, 1,160 r.p.m., 250 hp. ..... Buffalo Forge Co.
Induced-draft fan, 183,000 c.f.m. at 410 deg. F., 11.5 in. water, 865 r.p.m., 500 hp. ..... Buffalo Forge Co.
All fans driven at constant speed by Westinghouse 2,300-volt motors
Turbine-generator, one, 10,000 kw., 0.8 p.f., 3 phase, 60 cycles, 11,000 volts, 3,600 r.p.m. ... General Electric Co.
Steam conditions 1,250 lb., 750 deg. F., back pressure 235 lb. g., 20 per cent superheat. Water rates:

| Load Kw. | Lb. of Steam | B.t.u. Exhaust | Superheat in Exhaust, Deg. F. |
|---|---|---|---|
| 4,000 | 36.95 | 1,241.9 | 63 |
| 7,000 | 30.45 | 1,224.5 | 36 |
| 10,000 | 28.00 | 1,215.2 | 21 |
| 10,870 | 27.60 | 1,213.8 | 19 |

Back-pressure governor ..... General Electric Co.
Relief valve in turbine exhaust, Crosby Steam Gage & Valve Co.
Generator air coolers ..... General Electric Co.
Oil coolers ..... Andale Co.
Auxiliary oil pump ..... General Electric Co.
Oil switches ..... Allis-Chalmers Mfg. Co.
Switchboard ..... General Electric Co.

purities and with a maximum concentration in the shells not exceeding 250 gr. per U. S. gal. This concentration will be maintained by the use of a continuous blow-down system which salvages the flash steam at 2 lb. pressure and heat of liquid above 100 deg. F.

The evaporators are each 9 ft. in diameter by 28 ft. $8\frac{1}{2}$ in. long. Their welded shells (A.S.M.E. Class I) are of $1\frac{1}{4}$ in. plate with one integrally welded formed-steel head and one flanged removable formed-steel head. Welds in these shells were also X-rayed and stress-relieved. Each evaporator unit has 4,320 sq.ft. of effective coil surface made up of 1-in. O.D. No. 16 B.W.G. arsenical copper tubes assembled in the top and bottom headers with Parker fittings.

The evaporator drip cooler consists of a floating-head, removable-bundle multipass heat exchanger, and is interposed between the surge tank and the boiler feed-pump suction. This exchanger lowers the temperature of evaporator drips and thereby lessens the possibility of flashing at the boiler feed pumps.

Of the same construction as the evaporator drip cooler, the make-up condenser supplies condensate to replace any loss from the high-pressure system.

The evaporator feed heater is a horizontal, floating-head, removable-bundle unit of the multipass design. Both fixed- and floating-head water boxes have lock-head quick-removable covers. This exchanger further heats the feedwater before it enters the evaporators.

The evaporator and heat-exchanger system is designed to receive 300,000 lb. of exhaust steam per hr. from the high-back-pressure turbines, this steam being condensed in the coils and repumped to the boiler, thus practically eliminating any make-up for the 1,400-lb. boiler. We believe that this system assures maximum protection and reliability for this type of equipment.

A water-softening system could have been purchased for a lower capital investment, but evaporators had these advantages:

1. Water for a 1,400-lb. boiler has never been chemically softened; in this case if the turbine exhaust were led directly to the process steam lines makeup requirements would have been approximately 80 per cent.

2. The total solids in our raw water supply are rather high, reaching a peak during the past year of 30 gr. per U. S. gal., 20 gr. of it sodium chloride, and necessitating excessive blowdowns even if the water could have been treated successfully.

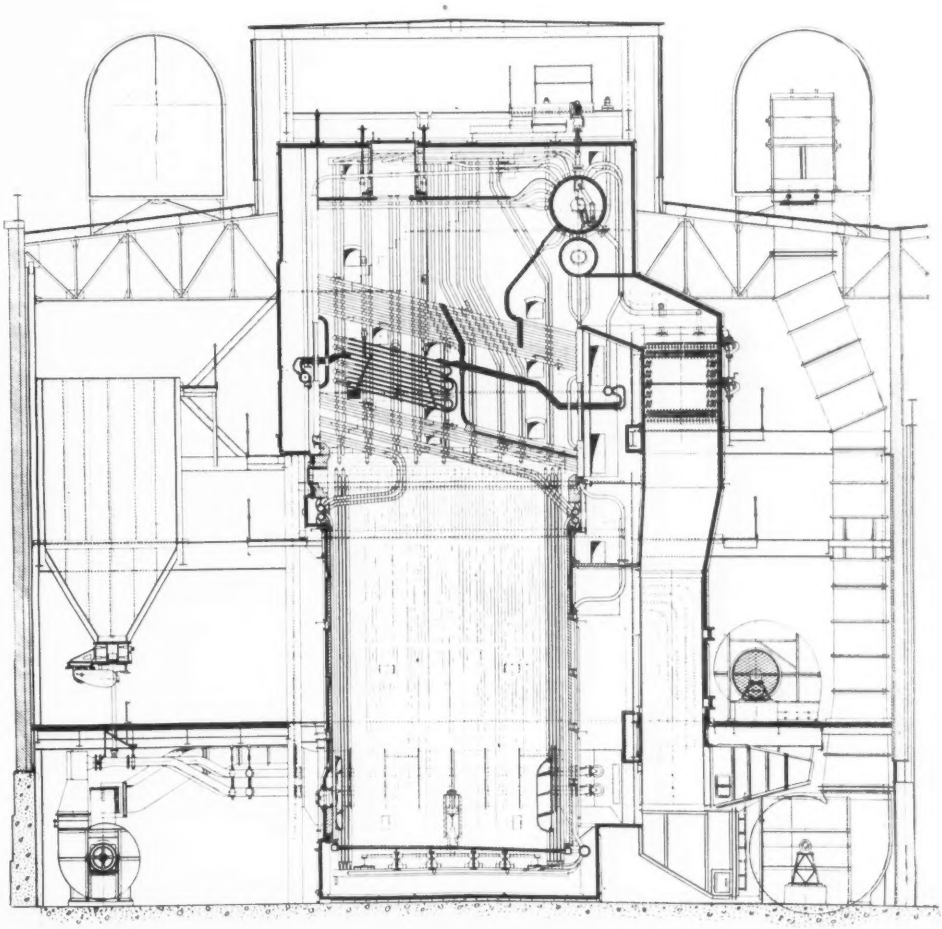
3. Evaporators minimized the possibility of solid carry-over from boiler to turbine, with resultant troubles and outages.

4. They avoid probability of boiler failure, high maintenance, and the ever-present necessity (with the softener system) of accurate and infallible human control—all for the possibility of a slightly greater return on the investment.

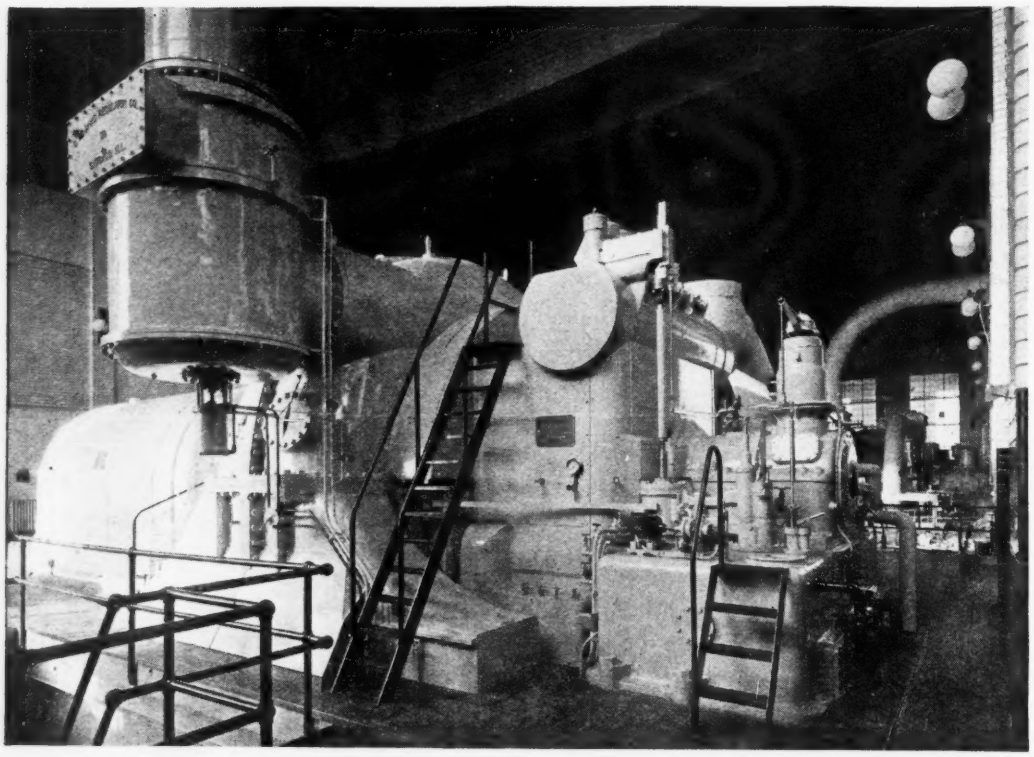
Feedwater is delivered to the boiler by two 7-stage turbine-driven pumps, one a spare. Each pump has a capacity of 850 g.p.m. when operating at full speed of 3,550 r.p.m. The pumps handle a total head of 3,604 ft., not including the 235 lb. on the suction. They have triple-labyrinth stuffing boxes at both ends and cooling facilities to preserve the packing and reduce leakage. The balancing line, which normally returns to the suction, has been piped to the surge tank, which allows some flow through the pump at shut-off. This has the additional advantage that the water circulating through the idle pump keeps it warm and ready for emergency service.

The turbines are equipped with overspeed and pressure-control governors. Also a quick-opening valve is installed in the steam line ahead of the governor. This valve opens and immediately starts up the spare pump if the pressure in the feed line drops below a predetermined point. Water supply to the boiler is regulated by a drum-level controller around which a bypass is installed for hand regulation. When on automatic control, only 75 lb. in excess of drum pressure is required to feed the boiler properly.

Steam supply for the boiler feed pump turbine is taken from the 225-lb. station header which supplies steam to the condensing turbine. This arrangement gives us maximum reliability for feed-pump operation.



**Boiler cross-section**



First of three 30,000-kw. 600-lb. pressure turbine-generators installed at Connors Creek Station

# REVAMPING CONNORS CREEK

*By Thomas Wilson*

REVAMPING of Connors Creek Station of Detroit Edison Company is in progress, the program to extend over several years. The initial installation, consisting of one 30,000-kw. turbine-generator replacing a 20,000-kw. unit and one new boiler, is in operation. Two other 20,000-kw. units are being replaced and three new boilers installed. Careful estimates indicate that station heat rate ultimately will be reduced from just above 19,000 B.t.u. per kw.-hr. in the old plant (fully loaded) to something less than 13,000 B.t.u. in the rebuilt station. This 32 per cent reduction is to be accomplished by raising steam conditions at the turbine throttle from 225 lb. and 600 deg. F. to 600 lb. and 825 deg. and by new double-ended bent-tube boilers with air preheaters and economizers, each unit evaporating 330,000 lb. per hr.

Specially developed underfeed stokers with an elaborate system of metered air control will burn continuously, and without smoke, 58.3 lb. of high-grade West Virginia or Eastern Kentucky coal per sq.ft. of projected grate area. These changes, plus stage-heating of feedwater, will produce an estimated over-all plant thermal efficiency of 26 per cent under varying load.

The slight efficiency advantage of an entirely new plant is more than offset by the lower cost of using the same building and much of the auxiliary equipment.

In the turbine room it was found possible to retain the old condensers and their auxiliaries. Stage bleeding and increased initial pressures reduced the work for the condenser so that the surface available would serve turbines of 50 per cent greater capacity. It was even possible to use the old foundation, exhaust casing, pedestal bearings, oil base and parts of the atmospheric relief valves. Two larger generators, one from Connors Creek and one from Delray, will be coupled to the first two new turbines.

Twenty years ago the initial installation of three 20,000-kw. turbine-generators went into operation. Later two 45,000-kw. single-cylinder turbine units were installed. To increase reserve turbine capacity, a 30,000-kw. unit was added in 1920, in a separate room at one end of the boiler house. These six units gave a station rated capacity of 180,000 kw.

All six turbines were designed to operate with steam entering the throttle at 225 lb. gage and 600 deg. Single- or 2-pass surface condensers were bolted to the exhaust nozzles of the turbines. Condensing surface ranged from 1.33 to 1.7 sq.ft. per kw. of generator rating. Single circulating pumps of 36,000-g.p.m. capacity served each of the three smaller units. For the three larger machines duplicate circulating pumps of 60,000 and 30,000 g.p.m. were used.

With the exception of three turbine-driven stand-by boiler-feed pumps and one general service pump, all auxiliaries were motor driven, d.c. units driving those auxiliaries essential to continuous operation. Six house

turbine-alternators and six synchronous-motor d.c. generator sets were provided to supply the auxiliaries. House turbines, operated in synchronism with the main units, drove the motor-generator sets directly to give d.c. power independent of the main units, or could be connected so that power would flow to or from the main system according to whether the output of the house unit was greater or less than the load on its own motor-generator set.

Interconnection of main and auxiliary power made it possible to adjust house turbine load so that the quantity of auxiliary exhaust steam would maintain desired boiler feed temperature. House turbines exhausted to five barometric condensers, known as heater condensers. Cooling water for these condensers was the condensate from the main surface condensers, so that the condensers on the auxiliary system served as feed-water heaters on the main system. Hot water was discharged through the barometric legs into hot boiler feed tanks from which it was drawn by the boiler feed pumps.

Fourteen boilers of the Stirling "W" type, each with 23,653 sq.ft. of effective heating surface, were arranged in two rows lengthwise of the boiler room. Each furnace was fired by two 2-ram underfeed stokers of 13 retorts each, one on each side of the boiler. Three 74,000-c.f.m. blowers served each pair of boilers.

## Coal-Handling

The coal-handling system is being retained to serve the revamped plant. At present, coal is received by boat, although it may also come by rail. Coal from the dock is loaded into railroad cars by a dragline scraper. Cars may then be discharged immediately into four track hoppers for crushing and delivery to the bunkers, or they may be emptied into the 150,000-ton storage yard by locomotive cranes. Yard storage capacity is sufficient to carry the plant during the winter when navigation ceases on the Great Lakes.

From the bottom of each track hopper coal is carried by an apron conveyor to a 200-ton coal crusher. Four crushers deliver to vertical bucket conveyors which girdle the boiler room transversely. Here three sets of belt conveyors at right angles to the bucket conveyors make it possible to deliver to any desired bunker.

From the plan view of the station the revised arrangement may be readily explained. The new plan ultimately calls for a generating plant of four 60,000-kw. and three 30,000-kw. turbine-generators. The three smaller machines, designated as units Nos. 8, 9 and 10, are being installed. No. 8 is already operating; the other two units of this group will be ready for service by the fall of 1935. The new turbines have one 2-row and 17 single-row stages and are bled at four points. The generator for one unit was taken from the 30,000-kw. unit originally placed in a special room at the end of the boiler house. For the second main unit, the generator comes from an available unit at Delray Station. The third 30,000-kw. generator will be new.

The flow diagram for the new 30,000-kw. unit makes an interesting comparison with the steam cycle of the old station. Introduction of regenerative heating required the installation of four closed heaters, two of the horizontal high-pressure 4-pass condenser type with desuperheat zones and two low-pressure 4-pass heaters. Steam is bled to these heaters from the fourth, eighth, eleventh and fourteenth stages of the turbine.

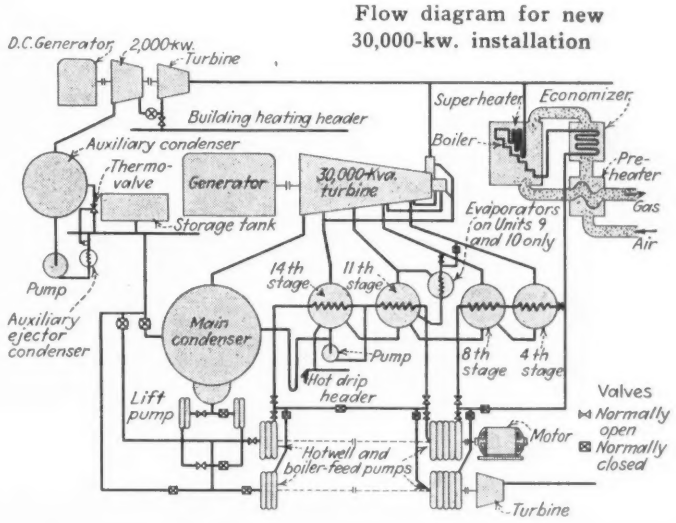
## Condensate

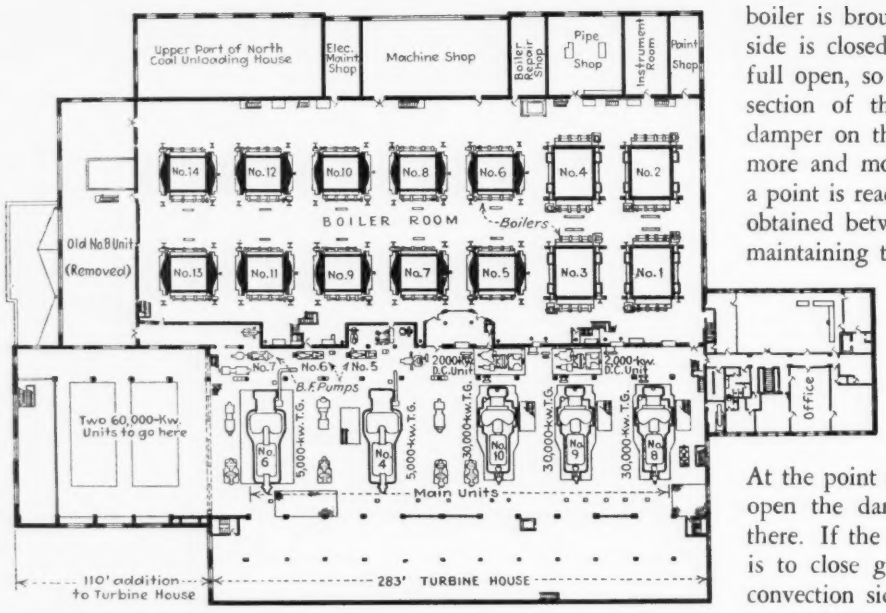
Condensate is drawn from the condenser well by either of two duplicate motor-driven lift pumps. These discharge directly to the hotwell pumps, which are mounted on the same shafts as the boiler-feed pumps. One of these combination units is motor driven, the other has a turbine drive, both requiring variable speed. Direct connection of these pumps to the condenser as hot-well pumps was not considered desirable as their speed would have caused undue cavitation. It will be seen that condensate passes from the 14th- and 11th-stage heaters to the boiler-feed pumps, then is forced through the two remaining heaters to economizers and boilers. Evaporators will provide the necessary make-up for Units 9 and 10. Make-up water for the first unit is being furnished from the evaporators in the old section. Steam will be drawn from the 8th-stage bleeder line, and the vapor will be flashed into the 11th-stage heater.

Power for auxiliaries is to be furnished by a new house unit consisting of a 2-cyl. cross-compound turbine geared to a 240-volt d.c. generator. During the summer this machine will operate full condensing. Condensate from the auxiliary condenser is used as the circulating water in the inter-and-after condenser of the steam-jet air ejector and is finally delivered to the main condenser or the storage tank. Water from the auxiliary condenser or the storage tank is passed through the main condenser to effect complete deaeration.

During the colder months steam will be bled from the high-pressure cylinder of the auxiliary turbine into the building heating header. Just enough steam at 10 lb. pressure, about 700 lb. an hr., will pass along to cool the low-pressure cylinder of the turbine. This small amount of steam does not give enough condensate for proper functioning of the inter-and-after cooler of the steam-jet ejectors. The latter is designed for a 15-deg. rise and requires approximately 10,000 lb. of water per hr. A thermostatic element in the outlet of the cooler recirculates enough water from storage to maintain normal temperatures.

**Flow diagram for new 30,000-kw. installation**






**Operating floor plan at Connors Creek**

In the steam-generating department of the plant, Boiler No. 1 is in operation, supplying the first of the 30,000-kw. units. Boiler No. 2 is nearly ready and the third and fourth units will be in commission by next fall, thus providing four boilers (one a spare) for the three 30,000-kw. machines.

For the higher steam pressure and temperature, double-ended boilers of the bent-tube 6-drum type have been selected. The boiler proper has about 3,000 sq.ft. more of steam-making surface than the older boilers. With additional surface in the water walls and the economizers, preheaters that give a maximum combustion air temperature of 423 deg. F., more effective stokers, and operation at higher ratings, capacity per boiler has been increased about 150 per cent. The new boilers are fitted in on the same column centers and mounted on the same steel work, but approximately two stories more headroom is required for auxiliaries.

The sectional elevation of the boiler shows that gas makes four passes along the tubes, and passes out between the drums on either side. Outlets converge into a central uptake rising to the top of the economizers. From here the flow is downward through an economizer on either side. From the economizers the gas makes a 180-deg. turn to drop out the dust and soot into collecting hoppers, then passes upward through plate-type preheaters to induced-draft fan and stack. The forced-draft fan at the same level draws air heated by radiation from the boilers and forces it down through preheaters and ducts to the wind boxes.

One feature of the new boiler is the compensating superheaters which will hold 850-deg. steam temperature within 5 deg. plus or minus. With a clean boiler the station staff has maintained this close regulation while burning from 6,000 to 30,000 lb. of coal an hr.

The right side of the V-type boiler has two superheating elements, one a semi-radiant superheater in the first bank of tubes, the other a convection superheater back of the radiant element. In the left side only a radiant superheater has been installed. When the boiler is brought up to load, the damper on the left side is closed and the damper on the other side left full open, so that most of the gas flows through this section of the boiler. As the rating increases, the damper on the left side is gradually opened, causing more and more of the gas to flow to the left, until a point is reached where an even division of the gas is obtained between the two halves of the boiler, while maintaining throughout a constant steam temperature.

At the point of equal division, an interlock trips wide open the damper on the radiant side and leaves it there. If the load continues to rise, the next operation is to close gradually as required the damper on the convection side. With a drop in load, operations are reversed. Damper operation is manual.

Another innovation is the use of soot blowers of integral type in preference to revolving elements. In effect, sections of smaller tubes are welded onto the boiler tubes. On these, nozzles are properly spaced and directed. Quick-opening valves outside the setting admit steam. All valves on one side are opened at the same time, so that blowing can be done in one "puff," rather than blowing the soot from one section to another, as has been common practice. With this construction there is no warping nor sticking, and elements do not burn out.

Double-ended underfeed stokers, developed from experience at Delray Station, serve the new boilers. They have 12 retorts, and the normal depth of 29 tuyeres has been increased to 41 by using thinner tuyeres. The coal-burning capacity of the double stoker is 32,500 lb. per hr. at normal full load.

Experience previously obtained with metered air control at Beacon Street heating plant led to its use in these units. Briefly, the double-ended stoker is divided into zones carrying across the stoker, and each of these zones into twelve divisions in accordance with the number of retorts. In projection, this sectionalizing would resemble an egg-crate division with 72 sections. Dampered inclosures opening into the windbox lead to each section. All are equipped with venturi nozzles, so that it is possible to meter the air going to each section of the grate and adjust supply according to the metered indication. At Beacon Street, control was manual, but in the present installation zone control has been made automatic. More complete details of this zoned air control will be given in a later article.

Higher pressures and temperature required new piping for steam and water. In erecting it fusion welding by the d.c. metallic-arc process has been employed. Pipe-to-pipe welding offered no difficulties, but welding pipe to castings, such as valve bodies, required expenditure of about $50,000 in research.

After extensive investigation, the decision was made to weld throughout the main and auxiliary superheated steam piping systems operating at 650 lb. pressure,

## PRINCIPAL EQUIPMENT IN REVISION

### Connors Creek Station

**Boiler Room**

Boilers, 4 double-ended, bent-tube, 6-drum, 26,764 sq.ft., 330,000 lb. normal full load 710 lb. gage pressure, effective bare water wall surface, 3,114 sq.ft., integral black surface 303 sq.ft., furnace volume 11,000 cu.ft. .....Combustion Engineering Co.
Superheater, Elesco compensating type, radiant surface 4,632 sq.ft., convection surface 6,335 sq.ft. each boiler, final temperature 850 deg.....Superheater Co.
Economizer, 2 per boiler, norizontal single-pass, return-bend, five-tube, 17,240 sq.ft. per boiler.....
Combustion Engineering Co.
Air preheater, 2 per boiler, vertical counter-crossflow plate type, 28,980 sq.ft. per boiler.....
Combustion Engineering Co.
Stokers, Taylor, double-ended underfeed, 12 retorts, 29 tuyeres, projected grate area 557 sq.ft. Coal capacity 32,500 lb. per hr. Stoker drive 2½-15 hp., 250-2,000-r.p.m., Westinghouse. Clinker-grinder drive 5-hp., 250-2,000-r.p.m. General Electric....
American Engineering Co.
Forced-draft fan, 1 per boiler, double-inlet Sirocco, 101,000 c.f.m. at 68 deg. 15.78 in. pressure. Westinghouse d.c. motor drive 50-400 hp., 370-740 r.p.m. .....American Blower Co.
Induced-draft fan, 1 per boiler, double-inlet, Sirocco, 181,000 c.f.m. at 346 deg., 15 in. pressure. Westinghouse d.c. motor 88-700 hp., 365-730 r.p.m.....
American Blower Co.
Feedwater regulators, 2 per boiler, (Copes)
Northern Equipment Co.
Soot blowers, integral type..Diamond Power Specialty Corp.
Safety valves, 3 per boiler
Crosby Steam Gage and Valve Co.
Blowoff valves, 4 per boiler.....J. Hopkinson & Co., Ltd.
Water columns, 4 per boiler.Diamond Power Specialty Corp.
Main steam valves .....The Lunkenheimer Co.
Motor operators .....Cutler-Hammer, Inc.
Coal spreader, conical type .....Stock Engineering Co.
Zone air control—air-loaded diaphragm controllers actuating hydraulic cylinders .....A. W. Cash Co.

**Turbine Room**

Turbine-generators, three, 30,000-kw., one 2-row Curtiss and 17 single-row stages, 4 bleed points, 1800-r.p.m., 600-lb. 825-deg., direct-connected generator*, 37,500 kva., 0.8 p.f., 12,200 volts, 140-kw. exciter, 250 volts .....General Electric Co.
Condensers*, three 2-pass, 27,000-sq.ft.
Worthington Pump & Mach. Corp.
Dry vacuum pump*, 1 per condenser, 2-stage, single-acting, Laidlaw-Dunn-Gordon. General Electric, d.c. motor, 12-40 hp., 30-100 r.p.m.
Worthington Pump & Mach. Corp.
Circulating pumps*, one per condenser, 42-in. volute, 36,000-g.p.m., driven by General Electric d.c. motor 200-250 hp., 280-375 r.p.m.
Worthington Pump & Mach. Corp.
Oil coolers*, duplicate, vertical .....Schutte-Koerting Co.
Generator air coolers*, 1682 sq.ft. ....General Electric Co.
Auxiliary turbine, 2,150-kw., cross-compound, 600 lb. gage, 825 deg. High-pressure turbine, 4,996-r.p.m. Low-pressure turbine, 3,622 r.p.m. Generator, 2,000 kw., 240 volts d.c., 450 r.p.m. ....General Electric Co.
Auxiliary condenser, 2-pass, 2,200 sq.ft., welded shell
Worthington Pump & Mach. Corp.
Auxiliary circulating pump, 1 per condenser, 17½ in. volute, 21 ft. head, 2,700 g.p.m., Westinghouse d.c. motor, 25 hp., 450-900 r.p.m.
Worthington Pump & Mach. Corp.
Auxiliary dry vacuum pump, twin-element, 2-stage, steam-air ejector, inter-and-after cooler
Worthington Pump & Mach. Corp.

**Feedwater System**

Stage heaters, two horizontal high-pressure 1,000 lb., 302,500 lb. water per hr.; two horizontal low-pressure, 4-pass, condenser type, water pressure 200 lb. .....Foster Wheeler Corp.
Storage tank, welded steel, 40,000 gal.
Combination boiler feed and hotwell pumps; two per main unit, boiler feed 647 g.p.m., 1,790 ft. head; hotwell pumps, 608 g.p.m., 284 ft. head. Westinghouse 4,800-volt, 3-phase, slip-ring motor, 101-505 hp., 1,412-1,780 r.p.m. Turbine drive 550 hp., 1,780 r.p.m. .....De Laval Steam Turbine Co.
Lift pumps*, two per main unit, 660 g.p.m., 140-ft. head. General Electric d.c. motors 35 hp., 1,200 r.p.m. .....Worthington Pump & Mach. Corp.
Heater-drain pump, one per main unit, 203 g.p.m., 440-ft. head. Westinghouse d.c. motor, 50 hp., 1,620-1,830 r.p.m. .....De Laval Steam Turbine Co.
Hot-drip pump, 200 g.p.m., 100-ft. head. Westinghouse d.c. motor, 900-1,800 r.p.m., 10 hp.
Pennsylvania Pump & Compressor Co.
Auxiliary unit hotwell pump, 65 g.p.m. 135-ft. head. Westinghouse d.c. motor, 7½ hp., 1,750 r.p.m.
Worthington Pump & Mach. Corp.

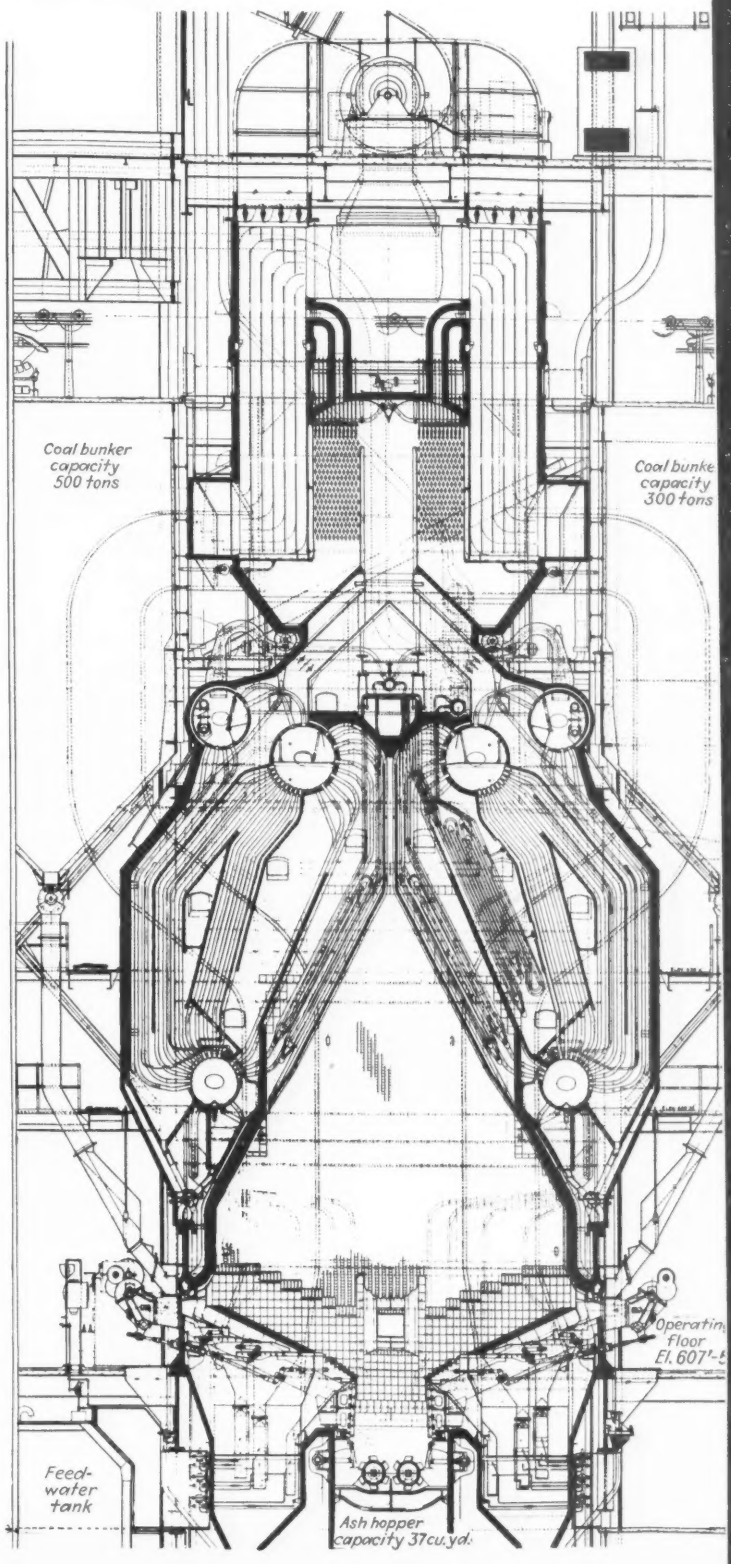
**Instruments**

Draft gages, special differential .....Hays Corp.
Air-flow meters .....Hays Corp.
Steam flowmeter .....Bailey Meter Co.
Pressure gages .....Consolidated Ashcroft-Hancock Co.
Temperature indicators and recorders.Leeds & Northrup Co.
Electrical meters .....Weston Elect. Instrument Co.
Tachometer .....Electric Tachometer Co.

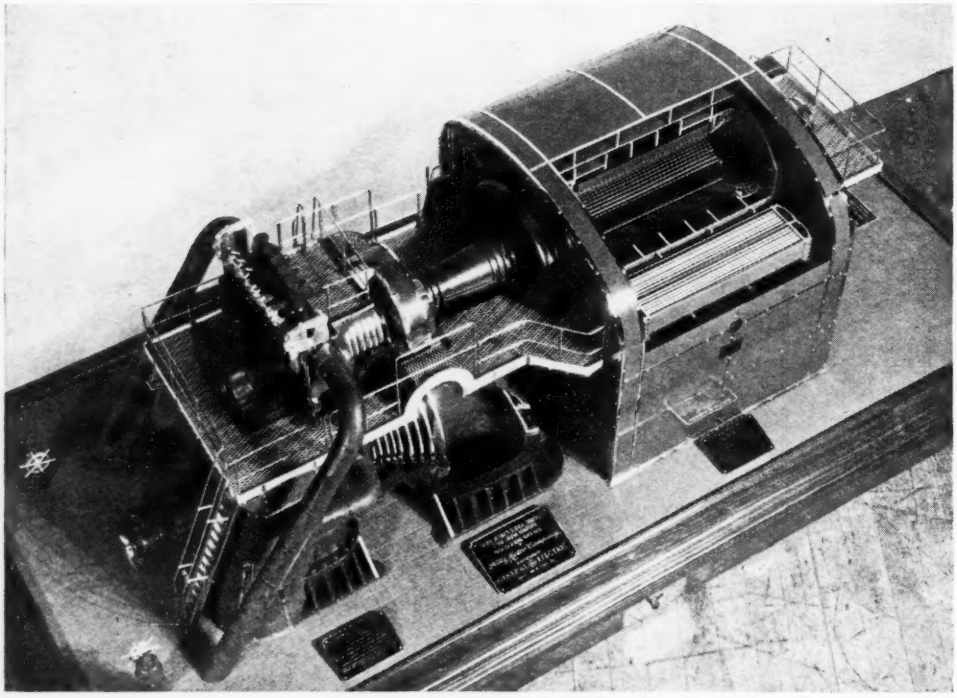
*Old equipment reused.

850 deg. F., and the boiler feed piping system in which pressure is 1,000 lb. and temperature 385 deg. In superheated steam piping there are no flanged joints between superheater outlet header and inlet end of the turbine stop valve. All valves except the last-named are welding-end type. Most welds are butt type with chill sleeves inside. Standard seamless steel pipe having 0.35% max. carbon by weight is used. Valve bodies are special chrome-nickel steel Alloy H.

**Sectional elevation through new "VV" boiler with capacity to deliver 420,000 lb. of steam per hr.**


Coal bunker capacity 500 tons
Coal bunke capacity 300 tons
Operatin floor El. 607'-
Feed-water tank
Ash hopper capacity 37 cu.yd.

Ford



**WORLD'S LARGEST**

**1,400-Lb. Plant (235,000 kw. with new unit)**
**1,400-Lb. Boiler (900,000 lb./hr. at 900 deg.)**
**1,200-Lb. Turbine (110,000 kw.)**

**Fig. 1—Model of first 110,000-kw. unit at Rouge, which new machine will resemble**

TO MEET growing power demands on its Rouge plant, occasioned by the new steel mill and other requirements, Ford Motor Company is installing a second 110,000-kw. double-deck vertical-compound turbine-generator with the necessary auxiliaries, and an additional high-pressure boiler to deliver (maximum) 900,000 lb. of steam per hr. at 1,400 lb. and 900 deg. One of the 30,000-kw. turbines of Ford design has been removed and three more will be dismantled; they cannot complete economically with the new high-pressure units.

Peak loads on the plant now run up to 120,000 kw., and the new steel mill will probably call for another 35,000 kw. With only the first high-pressure unit to draw on, it has been necessary to tie in with the Edison mains with an arrangement for interchange of power up to 60,000 kw.

### Process Steam from Turbine

A new 15,000-kw. non-condensing turbine unit, using high-pressure steam and exhausting at 250 lb. to process, will furnish additional power. To save condensate for boiler feed, its exhaust steam will pass to an evaporator generating vapor at 180 lb. for steam hammers a mile away, and for heating and other process work. This unit will furnish up to 450,000 lb. of steam per hr. The four old, low-pressure, pulverized-coal-fired boilers remaining in the Rouge plant will carry any additional process load. These boilers operate at 240 lb., capacity 500,000 lb. of steam per hr. each.

Like its predecessor, the new 110,000-kw. turbine will be the world's largest high-pressure unit, and the first large unit to use 900-deg. steam. Much of the equipment has been ordered. Work has begun on the turbine foundation, and it is expected that the unit will be ready to operate by April, 1936.

### New 110,000-Kw. Turbine

Except for minor changes in the boiler and the use of new turbine-blade material, the major changes from the first 110,000-kw. high pressure installation are the increase in steam temperature from 725 to 900 deg., and in boiler capacity from 700,000 lb. per hr. to 900,000. The higher steam temperature makes unnecessary live-steam reheaters such as are used between the high- and low-pressure elements of the first turbine. This saves much complication and expense and also gives a higher efficiency. Guaranteed B.t.u. per kw.-hr., not considering auxiliaries, are reduced from 9,675 to 9,000 B.t.u., turbine water rates from 8.93 to 8.3 lb.

One reason for practically duplicating the first unit is its fine performance; the first machine has operated 22,361 hr. out of a possible 30,000 hr. between July, 1931, and last December, generating 840,000,000 kw.-hr. in all. During this time there has been only one enforced shutdown to repair the admission valve. No major difficulty has been experienced with the generating unit nor with the boilers.

### World's Largest H.P. Boiler

For the present, one new boiler will take care of the turbine, but space is available for a future boiler of the

# ADDS 125,000 KW. AT ROUGE

*By Thomas Wilson*

same size. As indicated in Fig. 2, the boiler will be of the 5-drum, double-ended type common to the Rouge plant for a number of years. From the V-shaped combustion chamber the gases will divide between the two elements, one on either side. Traversing three passes in each boiler element, the gases move through the respective economizers and air preheaters to the induced-draft fans at the highest level, thence to the stack.

The fans will operate normally at a pressure of about 15 in. water. Forced-draft fans on the same level will draw the warm air from the top of the boiler room and discharge it through the preheaters to the furnace wall ducts and the burners. Drives for these fans will be 2-speed motors. Two blowers at a lower level will supply primary air carrying the fuel to the furnace.

In the two boiler elements there will be 616 3-in. tubes on 7-in. spacing and 1,180 $2\frac{1}{2}$-in. tubes on $5\frac{1}{4}$-in. spacing. The four drums having contact with the water will have forged cylindrical shells with pressed heads welded on. The two lower drums are 40 in. in diameter, 4 in. thick, 30 ft. long; two upper drums, 48 in. x $5\frac{1}{4}$ in. x $34\frac{1}{2}$ ft. From the two upper drums, evaporation passes to a welded steam-drum (40 in. x $3\frac{1}{16}$ in. x $24\frac{1}{2}$ ft.) centrally located above the setting. The lower part of the steam-drum shell will be made of thinner plate than the upper portion, since the former has no tube holes. Heads will be welded to the drums. It is proposed to weld the piping throughout in preference to the flanged fittings used with the first unit.

### One Superheat Header

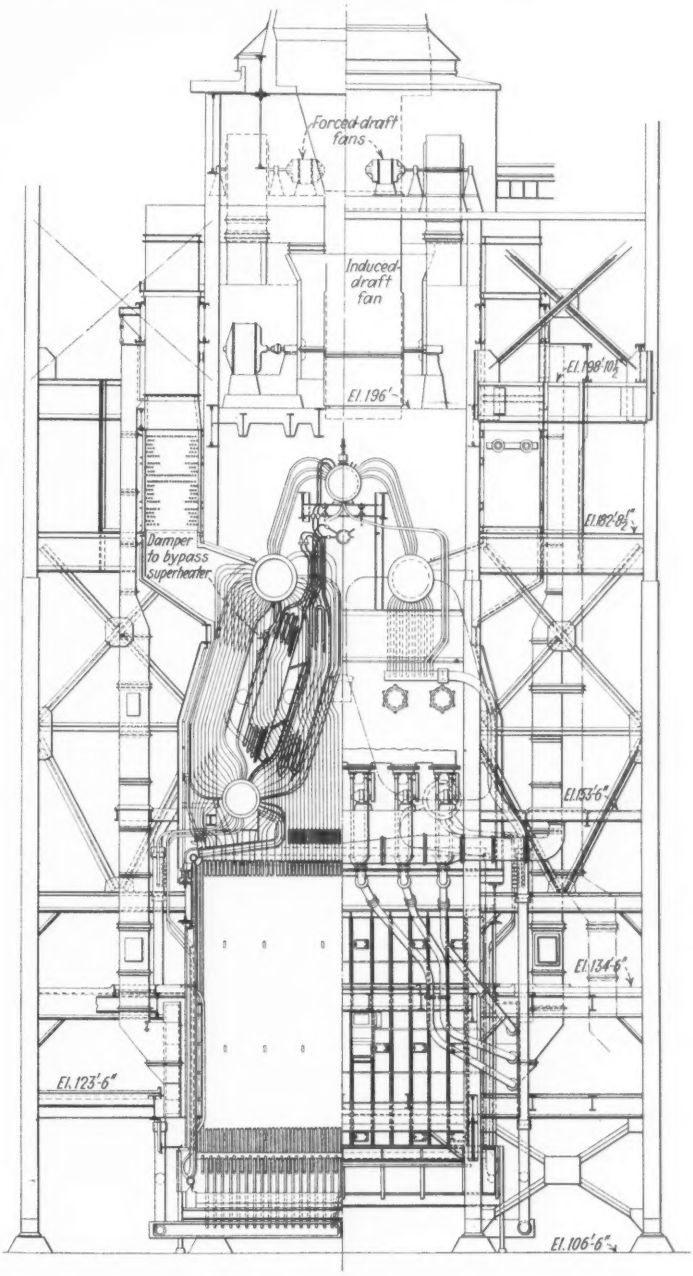
Formerly, three superheat headers were under the steam drum. In the new unit, one header will be used, and some variation will be made in the location of the superheating elements. There will be two superheater banks on each side of the boiler, one in the first pass just back of the first row of tubes so as to get some radiant effect, and the other element back of it in the second pass, with a damper arranged to bypass most of the gases from this element in case the temperature should rise too high. Gas temperatures in the first pass should range from 2,200 to 2,300 deg. Superheater surface will be proportioned to give 750-deg. steam. In the second pass, a gas temperature of 1,600 deg. will raise the steam temperature to the 900-deg. final temperature called for in the design.

To protect the walls of furnace and combustion zone to one-half the height of the boiler, fin tubes of 3-in. diameter inclose the fire. Water-cooled ash screens protect the furnace bottom. Through headers outside the boiler walls these tubes will connect into the boiler circulation, so that 7,200 sq.ft. of extremely active radiant surface will be added to the 30,000 sq.ft. of surface in the boiler.

By moving a girder that required a curvature in the furnace wall of the first unit, it will be possible to bring the wall tubes straight up into the header and increase the furnace volume to nearly 30,000 cu.ft. Fuel heat release rate at the maximum load of 900,000 lb. of steam per hr. will approximate 34,000 B.t.u. per cu.ft. of furnace volume.

The furnace will be arranged to burn three fuels: 100-B.t.u. blast-furnace gas, 550-B.t.u. coke-oven gas

**Fig. 2—Sectional elevation through the new boiler**



and powdered coal. The gas fuels will be auxiliary and burned only when not needed elsewhere. Gas burners will be located centrally in each front wall. Twelve pulverized coal burners will be divided into four sets to provide an upright row of three burners in each of the four corners of the furnace below the level of the gas burners. As in the initial installation, they will point tangentially toward an imaginary circle at the center of the furnace to form a whirling vortex of flame.

Guaranteed over-all efficiencies for the new boiler show an unusually flat curve over a wide range of load: 87.7 per cent at a steam output of 400,000 lb., 87.8 per cent at 600,000, 87.4 per cent at 800,000 lb., 86.6 per cent at 900,000 lb.

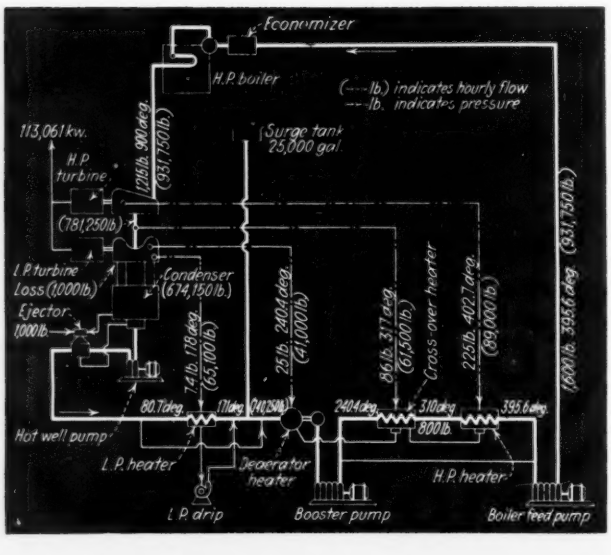
Turbine-generator unit will be similar in appearance and design to the first high-pressure machine, with the blading metal modified for higher temperature. Over-all dimensions will be slightly larger, 66 ft. long, 24 ft. 10 in. wide, 22 ft. 3 in. high to the top of the turbine control valve. Air coolers will be integral with the generators.

## Steeple-Compound

The new unit will have a horizontal steeple-compound turbine with the high-pressure cylinder mounted above the low-pressure. Each element of the turbine will have a separately excited 55,000-kw. generator, one mounted above the other in line with their respective turbines. The high-pressure turbine will have 12 stages and the double-flow low-pressure element 10 stages on each side of a central steam admission. Reheaters will not be needed with the higher steam temperature, so the high-pressure cylinder of the turbine will exhaust (at about 86 lb. abs.) directly into the low-pressure turbine. The official rating of the unit will be 110,000 kw. at 0.8 p.f. Three-phase 60-cycle current will be generated at 13,800 volts. Steam conditions at the throttle will be 1,200 lb. gage and 900 deg. F.

The single-pass 73,000-sq.ft. surface condenser will use vertical self-priming propeller-type circulating pumps.

**Fig. 3—Heat balance and flow diagram for the new 110,000-kw. unit**




## DATA ON 110,000-KW. ADDITION
### Rouge Plant, Ford Motor Co.

**(Preliminary; subject to change)**

Boiler: Double set, bent-tube, 5-drum, 30,000-sq.ft. heating surface; generating 900,000 lb. per hr. maximum, 800,000 lb. normal at 1,400 lb. and 900 deg. F.; over-all efficiency 87.8% at 600,000 lb., 87.4% at 800,000 lb.

Furnace: 30,000 cu.ft., releasing (max. load) 34,000 B.t.u. per cu.ft.; 7,200 sq.ft. total heating surface in water walls and grates.

Superheaters: Convection, 21,940 sq.ft.

Economizers: 2 fin-tube, 26,500 sq.ft. heating surface (combined)

Air Heaters: 2 vertical-plate counterflow, 224-element, 86,016 sq.ft. heating surface (combined)

Fans: 4 forced-draft, 70,000 c.f.m., each at 110 deg. and 12-in. w.g.; 2 induced-draft, 260,000 c.f.m., each at 365 deg. and 18-in. w.g.; 2 primary air, 50,000 c.f.m., each at 400 deg. and 16 in. w.g.

Booster Pumps: Two 2,535 g.p.m., 1,770 r.p.m., 78% eff., 1,771-ft. head, 247 deg., 1,375 b.hp., 1,500-hp. motor, 28.5 lb. abs. suction press., 28 ft. positive gravity head, 750-lb. discharge press.

Feed-Water Pumps: Two 2,800 g.p.m., 1,770 r.p.m., 75% eff., 2,300-ft. head, 407 deg. F., 1,855 b.hp., 2,000-hp. motor, 750-lb. suct. press., 1,600-lb. disch. press.

Deaerating Heater: One 610-cu.ft. storage, heats 1,283,280 lb. wtr. per hr. from 171 deg. to 240; steam supply 25 lb. abs.

Closed Heaters: Three, surface type: One low-pressure heater, 3,000 sq.ft., heating 668,000 lb. per hr. from 87 deg. to 171 with steam at 7.4 lb. abs.; one cross-over heater, 2,430-sq.ft., 4-pass, heating 840,000 lb. per hr. from 240 deg. to 310, with steam at 86 lb. abs.; one high-pressure heater, 2,430-sq.ft., 4-pass, heating 840,000 lb. per hr. from 310 deg. to 395 with steam at 225 lb. abs.

Turbine: Horizontal steeple—compound; high-press. cyl., 12 stages; low-press. cyl., 10-stages, double-flow; speed 1,800 r.p.m.; 2 generators, each 55,000-kw., 3-phase, 60-cycle, 13,800 volts.

Performance: (Estimates)—Throttle steam 1,215 lb. abs. and 900 deg. F.; high-press. cyl. exhausts at 86 lb. abs.; low-press. cyl. exhausts at 1 in. Hg.; 4-stage bleeding at 225, 86, 25 and 7.4 lb. abs. Throttle steam rate at 100,000 kw., 8.3 lb. or 9,000 B.t.u. per kw.-hr.

Condenser: Single-pass, surface, 73,000 sq.ft.

Circulating Pumps: Two, 54-in. vertical high flow, 18.42 ft. head; 58,700 g.p.m. each; 325 b.hp.; 300 r.p.m.; 84% eff.

Steam air ejectors: Two double-ejecting units with two 2-stage elements; use steam at 130 lb. gage, 650 deg. F.; condense 2,500 lb. steam per hr.

Back-pressure turbine-generator: 15,000 kw. at 0.8 p.f.; horizontal non-condensing, exhausting at 250 lb. gage to process; generator 3-phase, 60-cycle, 13,800 volts, 3,600 r.p.m.; direct-connected exciter.

Hotwell Pumps: Two, 10-in., 3-propeller, 200-ft. head, 2,000 g.p.m.; 140 b.hp., 900 r.p.m.; 68% eff.

## Hook-Up

As with the first unit, steam will be extracted from four stages of the turbine for feed heating. The accompanying heat balance and flow diagram show the proposed arrangement of the cycle. The four points are: from the high-pressure turbine at 225 lb. abs., from the cross-over connection at 86 lb. abs., two from the low-pressure turbine at 25 and 7.4 lb. abs., respectively.

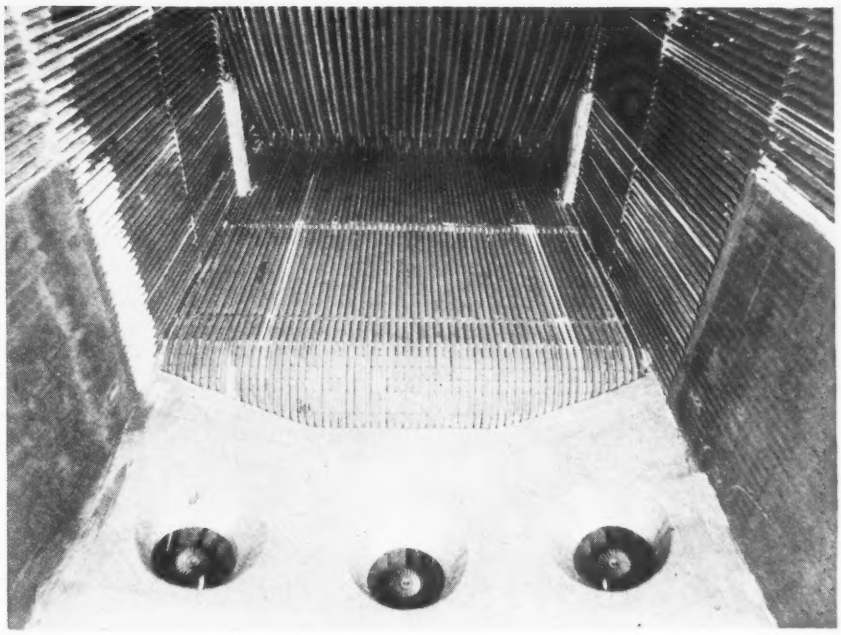
Condensate from the hotwell will be forced through the air-ejector condenser and the low-pressure closed heater to the deaerating heater. At this point distilled water from evaporators will be introduced as make-up. Booster pumps will force the boiler supply through the cross-over and high-pressure heaters to the boiler feed pumps. These, in turn, will force the feed water, at 1,600 lb. and 406 deg., through the economizers to the boiler. Heater drips will be cascaded from one to the other in the order of the pressure, and eventually be pumped back into the feed-water system.

With the completion of the present installation by April, 1936, the Rouge plant will have by far the largest station in the world operating at 1,400 lb. pressure. At that time the aggregate capacity will be 235,000 kw.

*By E. H. Barry*

*Power Supervisor,*
*W. Va. Pulp & Paper Co.*

**West Virginia Pulp & Paper Co., facing increased steam requirements at its Covington, Va., plant, installed 1934's largest boiler, a 450,000-lb.-per-hr. unit**



# 1 BOILER REPLACES 2 PLANTS

BEFORE September, 1934, West Virginia Pulp & Paper Co. operated three power plants at its Covington, Va., plant. These plants were interconnected with steam headers carrying 150-lb. and 25-lb. pressure steam, and with electrical lines. Two plants generated steam at 160 lb.; the third, installed in 1926 and 1928, contains four 425-lb. boilers, each capable of delivering 125,000 lb. (Max.) of 650-deg. steam an hour. This plant contains three 5,000-kva., 400-lb. turbines, one a condensing unit bleeding at 25 lb., the other two exhausting at 20 lb. and bleeding at 160 lb. to 11,300 kw. of low-pressure turbines.

In 1934, additional reserve boiler capacity was needed. We decided to revamp all power facilities and start a program of modernization which would eventually increase steam pressure to 600 lb. and concentrate all steam generation and power facilities in one boiler-house. The first step was installation of a boiler designed for 608 lb., 750 deg. and maximum steaming capacity of 375,000 lb. per hr. It is the largest industrial boiler placed in operation in 1934. Later, a 7,500-kva. 600 lb. turbine-generator, that has been in service in one of the other plants of the company will be installed at Covington.

Turbines now at the plant take steam at 400 lb. and 155 lb. pressure. Present plans contemplate alteration of the 400-lb. turbines so that they may operate at 600 lb., but until these alterations are made the new boiler will operate at approximately 450 lb. and deliver steam at something less than 700 deg. final temperature.

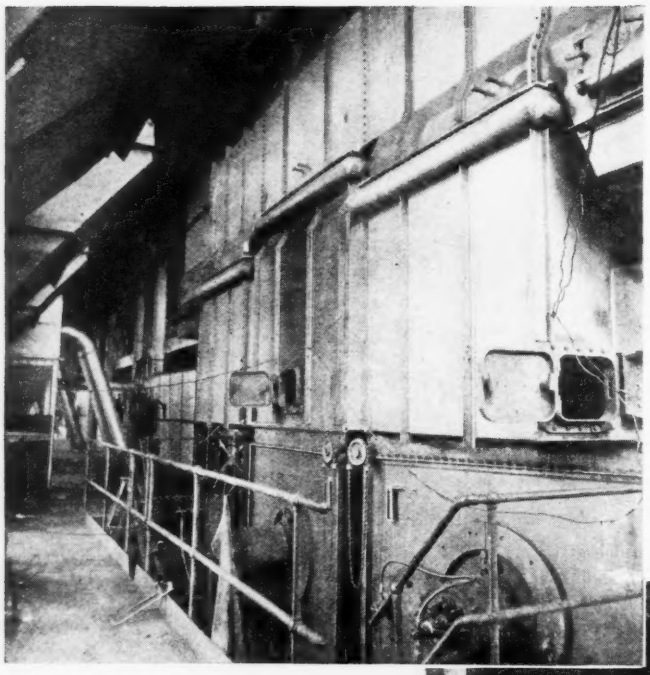
The 600-lb. boiler has been placed in an addition to the boiler-house that housed the old 400-lb. equipment. The building is of steel and concrete with brick outside walls. A concrete chimney, 225 ft. high, is at the top of an adjacent hill and serves all five boilers.

The boiler went into operation in September, permitting the two other low-pressure boiler plants to be shut down, and steam for operating the generating equipment in them is supplied from the single boiler-house. The new boiler has generated as much as 450,000 lb. of steam per hr., and we feel that its maximum rating has not yet been reached.

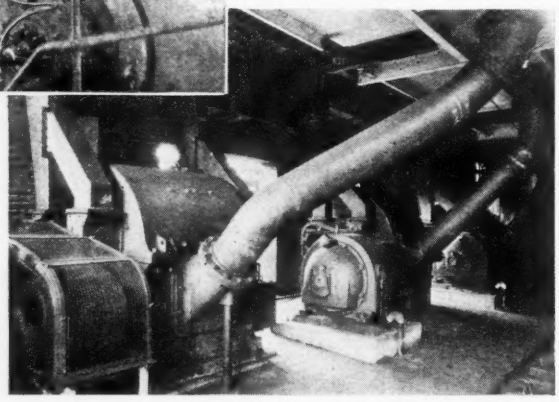
Coal-handling facilities of the old plant could be used, and the coal bunker distribution system and weigh larry were extended to the new unit. Coal from the weigh larry is discharged into a hopper above feeders on the operating floor which discharge to pulverizers on the lower floor. There are six feeders in pairs, each pair feeding its own mill. Feeders are d.c. motor driven with speed controlled by field rheostats. A special interlocking device between feeders and mills operates when the mills become overloaded. Feeders are first slowed down, then stopped if overload continues. The three duplex Atrita-type mills, each of 13,000 lb. per hr. capacity, receive coal at both ends and discharge at the center, each delivering to a single burner. There are no cross-connections between mills and burners.

Horizontally-fired turbulent-type burners are arranged side by side in the lower portion of the front wall but far enough above the furnace floor to prevent slagging of the ash. The two outside burners are toed in to prevent flame impingement on side walls and create a higher degree of turbulence in the furnace. Front wall is air cooled, air being drawn in at the top and entering the furnace near the bottom. Auxiliary oil burners are provided for lighting coal burners and operation at low ratings.

Except for the front wall, the furnace, which has a volume of 18,200 cu.ft., is water-cooled. Designed heat liberation is 25,150 B.t.u. per cu.ft. per hr. Because high-grade New River coal, low in ash content, high in fusion temperature, is burned, it was possible to design



New 600-lb. boiler in foreground has produced 450,000 lb. of steam an hour



Pulverizers are fed at both ends and discharge at the center each to a single burner

the furnace with flat refractory bottom. Ash is removed by hand, while the boiler is on the line, through nine ash-removal doors in the lower portion of the rear and side walls.

Boiler proper contains 15,600 sq.ft. of heating surface. It is of the three-drum, bent-tube ring-flow type with a fourth drum used as a dry-steam drum. Each drum is formed from a single steel plate with one arc-welded longitudinal seam. Drum heads are welded on. The main steam drum is 51 in. inside, $3\frac{1}{8}$ in. thick and rests on saddles. The dry steam drum is hung by steel straps and the front water drum is supported by steel plates hung on trunnions. This permits the two front drums to move outward as the tubes expand. The mud-drum, supported by the boiler tubes, is free to move as required by expansion.

The superheater, above the third row of boiler tubes, is of the multiple-loop type, inlet tubes being rolled into the dry-steam drum, and outlet ends rolled into a header above and outside the boiler. The superheater was designed for 600 lb. operation even though it was expected the resulting steam temperature would be too high during 400 lb. operation. To prevent this a baffle was temporarily placed below it to shield a portion of its surface. This brought the steam temperature down, but at the expense of higher flue gas temperature and some loss in boiler efficiency. This baffle will be removed when the boiler is operated at its designed pressure.

Furnace and boiler are steel encased and water-wall elements are anchored at 10-ft. intervals to preserve alignment. Water walls consist of $3\frac{1}{4}$ in. tubing set on $4\frac{1}{4}$ in. centers, thus leaving only 1 in. clearance between elements.

The rear water wall is fed from the bottom boiler drum, downcomers being embedded in tile and insulation in back of the wall and under the casing. The steam and water mixture is discharged into the same drum. There are no recirculators.

The bottom header is partly within the furnace, waterwall tubes coming into it vertically. This same arrangement has been used for the two side walls, headers being refractory protected. These seamless-steel headers are of rectangular cross-section with walls nearly 2 in. thick.

Front-wall construction is similar to back-wall construction and it is fed and delivers to the front boiler drum. In this case, downfeeders come out of the drum above the waterwall risers, consequently it was necessary to install a baffle plate in the drum to prevent steam from being drawn down into the supply downcomer.

The side water walls are fed from the mud drum and discharge partly to the main steam drum, with another part going to the front drum.

All circulation piping of the water walls is contained inside of the steel boiler casing thus giving very clear cut appearance to the unit.

Flue gas leaves the boiler at the mud-drum level and passes to a two-pass, vertical, tubular 40,000-sq.ft. air preheater (directly behind boiler) which heats combustion air to 483 deg.

### Fly-Ash Removal

From the preheater, gas passes horizontally through duplicate wet-type gas scrubbers, then to induced-draft fans. The gas scrubber is a series of vertical baffle plates through which gas zig-zags horizontally, impinging against wet baffle faces at an angle. Water from a tank above flows over the plate surfaces and carries fly ash down and out through a discharge line leading to the sewer.

Two vane-control induced-draft fans deliver flue gas to a common station duct. Two vane-control forced-draft fans deliver combustion air through the air preheaters, thence through ducts on both sides of the boiler to the burners and pulverizers. Both the induced- and forced-draft fans have inlet-vane control and are driven by constant-speed motors. One fan of each type is capable of serving the boiler up to about 300,000 lb. per hr. Above this rating all four fans are required.

Under normal operation, flue gas from this boiler joins with gas from the other boilers and discharges

through the chimney on top of a neighboring hill. However, to study the gas from this particular boiler isolating dampers have been provided which divert the gas to a short stub stack.

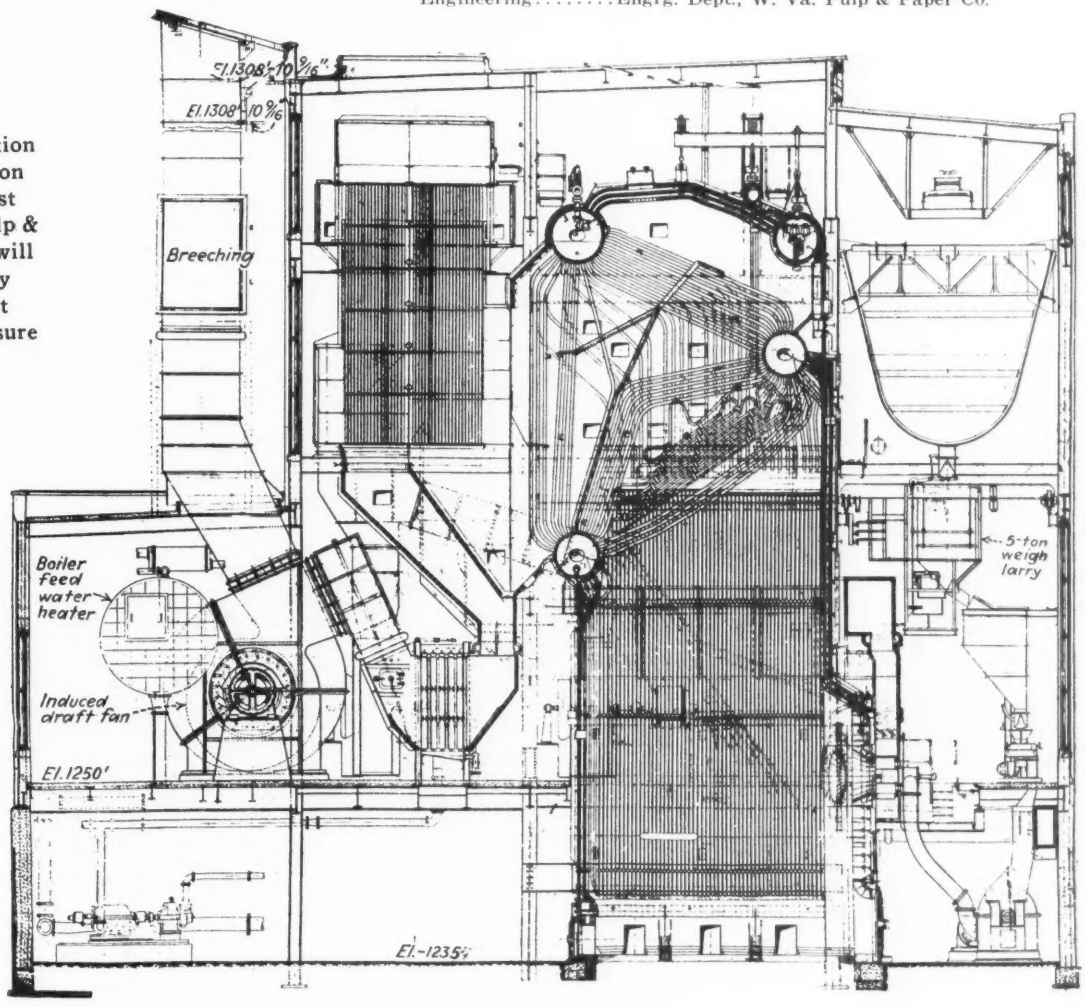
As a safeguard against starting auxiliaries in improper order, electrical interlocks prevent starting forced-draft fans, pulverizers, or coal feeds until an induced-draft fan has been started. The same interlocks result in a shutdown of the above auxiliaries in case the induced-draft fans shut down unexpectedly or through an operating error. A pressure switch likewise operates to shut down forced-draft fans, pulverizers, and coal feeders, if for any cause pressure is developed in the uptake.

Induced-draft fans are driven by 400-hp. motors, forced-draft fans by 250-hp. motors. These motors are designed for starting directly across the line. To avoid unnecessary load during starting, interlocks prevent starting of fans unless their inlet dampers are closed. Thus, the motors, in starting, have to overcome only inertia load of the fan impeller.

Operation of the boiler and its auxiliaries may be controlled from a panel in the operating aisle at end of building. On this panel are stop and start push buttons for across-the-line starters with indicator lights for feeders, motors, pulverizer motors, induced- and forced-draft fans. Operation of these units is normally under automatic combustion control, the instruments and controls being mounted on the boiler control panel. Among other instruments on this panel are boiler meter, pressure gages, boiler water level indicators, 10-point temperature recorder, and 8-point draft gage.

## PRINCIPAL DATA ON NEW BOILERS
### W. Va. Pulp & Paper Co., Covington Plant

Boiler, one 4-drum, ring flow, 375,000 lb. per hr. 608 lb. pressure, boiler surface 15,600 sq.ft., water walls 6,500 sq.ft., multiple loop superheater, 4,450 sq.ft. 725 deg. steam temperature, efficiency at 300,000 lb. 83.6%, furnace vol. 18,200 cu.ft., Riley Stoker Corp.
Air cooled front wall ..... M. H. Detrich Co.
Refractories ..... Harbison-Walker Refractories Co.
Air preheater tubular, 2-pass gas and air; surface 40,000 sq.ft.; leaving temp., gas 422 deg., air 483 deg. F. ..... Riley Stoker Corp.
Flue-gas scrubbers, 2 wet-type ..... Riley Stoker Corp.
Coal feeders, 6 ..... Riley Stoker Corp.
Pulverizers, 3 duplex, 13,000 lb. per hr. ..... Riley Stoker Corp.
Coal burners, 3, flare type ..... Riley Stoker Corp.
Oil burners, 3, steam-atomizing ..... Hauck Mfg. Co.
Automatic combustion control ..... Smoot Engineering Corp.
Steam purifier ..... Blaw Knox Co.
Continuous blowdown ..... Permutit Co.
Continuous sulphuric-acid feed ..... Permutit Co.
Feedwater regulator, 2 ..... Swartwout Co.
Water columns, gage glasses, 2 .. Reliance Gauge Column Co.
Soot blowers ..... Diamond Power Specialty Co.
Blowoff valves ..... Yarnall-Waring Co.
Safety valves ..... Consolidated Ashcroft Hancock Co.
Steam tempering valves and thermostats ... Swartwout Co.
Non-return valves ..... Davis Regulator Co.
Coal bunker ..... Frank M. Weaver & Co.
Forced-draft fans, 2, single-inlet, vane control, each 72,000 c.f.m., 14.4 in water, 250 hp. .. B. F. Sturtevant Co.
Induced-draft fans, 2, single-inlet, vane control, cap. each 102,500 c.f.m., 500 deg. F., 16.2 in. water, 400 hp. ..... B. F. Sturtevant Co.
Draft fan motors, 440-volt, 25-cycle, 725-r.p.m. constant-speed ..... Westinghouse Elec. & Mfg. Co.
Boiler-feed pumps, 2, 1,200-g.p.m., ..... Ingersoll-Rand Co.
Boiler-feed-pump turbines ..... Terry Steam Turbine Co.
Reducing valves and desuperheater . Smoot Engineering Co.
High-pressure valves .. Consolidated Ashcroft-Hancock Co.
Chapman Valve Mfg. Co., Crane Co.
Piping ..... Power Piping Co.
Hunter B. Frischkorn, Inc., M. W. Kellogg Co.
Benjamin F. Shaw Co.
Heat insulation ..... Chas. S. Wood & Co.
Wallace & Gale
Boiler meter ..... Bailey Meter Co.
Venturi meter ..... Builders Iron Foundry
Blowdown meter ..... Henszey Deconcentrator Co.
Recording pressure gage ..... Republic Flow Meter Co.
Indicating press. gages .. Consolidated Ashcroft Hancock Co.
Recording water-level indicators .. Republic Flow Meter Co.
Recording pyrometers ..... Leeds & Northrup Co.
Feedwater flow indicator ..... Morey & Jones
pH recorder ..... Leeds & Northrup Co.
Motor starters and controls . Westinghouse Elec. & Mfg. Co.
Engineering ..... Engrg. Dept., W. Va. Pulp & Paper Co.

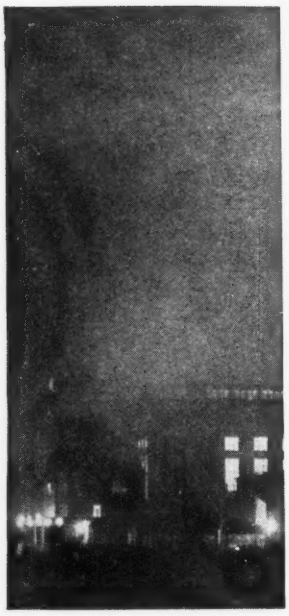



**Boiler addition to Covington plant, West Virginia Pulp & Paper Co., will eventually operate at 600-lb. pressure**

# LARGEST DIESEL
## Pinch-Hits for Steam

*By H. Walter Pye*
*Copenhagen, Denmark*

**Copenhagen's 22,500-hp. standby and peak-load unit goes from cold to "on the line" in 1 min. 40 sec.**

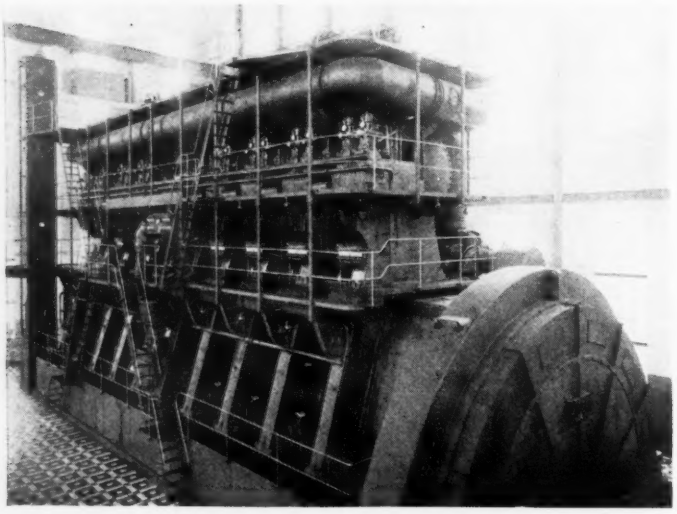


ONE of the largest and most interesting European power plants, the H. C. Oersted station at Copenhagen, has recently completed its third great extension and has been operating in its new form for somewhat over a year with very gratifying results. The rather unusual combination of steam and diesel, and the extraordinary size of the latter, have excited much interest and discussion in these countries, but only one description of the diesel has been published in America (POWER, October, 1932).

The first section, commenced in 1916, but (due to the difficulties imposed by the War) not brought into operation until 1920, had an aggregate machine power of 26,000 kw. in. three turbine-alternators, one of 6,000 kw. and two of 10,000 kw. The steam plant had ten water-tube boilers (each with 5,910 sq.ft. of heating surface) operating at 215 lb. pressure and 662 deg. F.

The second extension, begun in 1923 and concluded in 1926, added two turbine-alternators of 16,000 to 20,000 kw. and a second steam plant of eight 10,114-sq.ft. water-tube boilers. Steam pressure of 355 lb. and a temperature of 707 deg. F. were chosen for this extension. Generating capacity was thus raised to 58,000 kw., and distribution system transmission voltage was increased from 6,000 volts to 30,000.

**The 22,500-hp., 33x59-in. diesel, 36 ft. high by 66 ft. long. Notice elevator at left and man on platform**

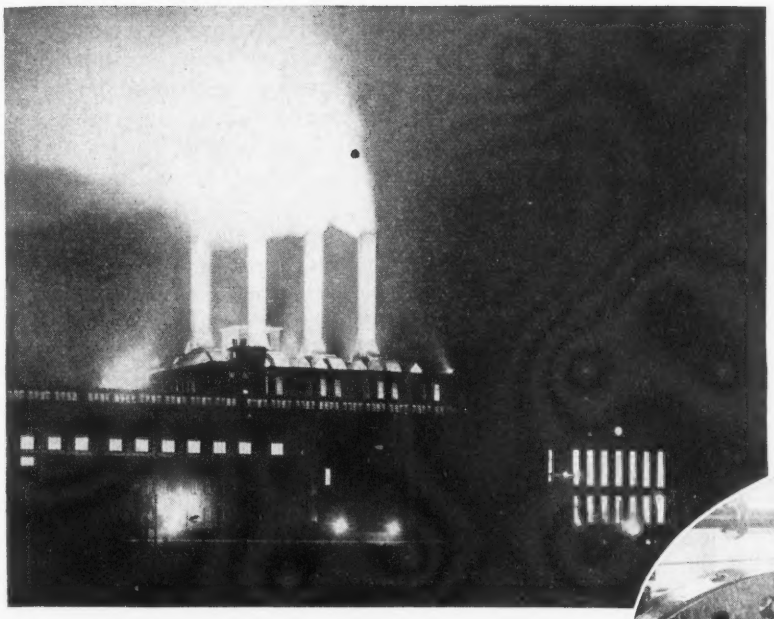


This brought about complete centralization of power production in Copenhagen, as the three other stations were wholly or partly rebuilt to converter substations. The slight remaining generating capacity was used only during winter peaks, while the old steam plants were used for district heating.

In 1929, growing peak loads indicated that a third extension should be in partial operation by the fall of 1932. Contributory factors were electrification of the Copenhagen District railroad lines and the projected extension of distribution throughout Sealand and a similar extension of the South Swedish Power Co. Denmark sends power across the Oresund by submarine cable to the Swedish hydro stations at times of low water, receives it at other times. Copenhagen municipality granted 20,000,000 kronen for this third extension, completed in the summer of 1933.

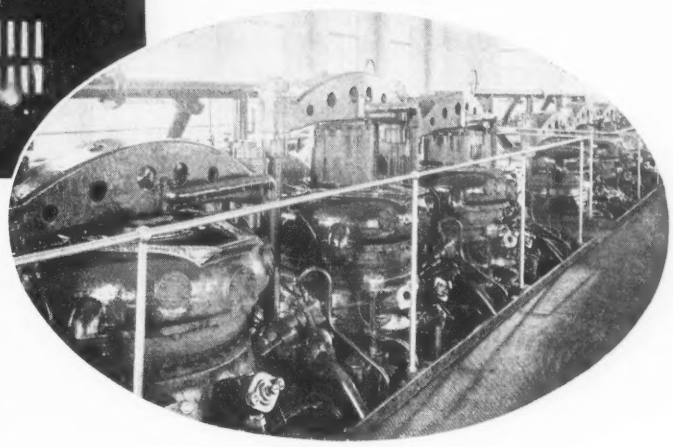
This last enlargement of Oersted Station has been basic in character and adds an enormous steam and turbine power capacity coupled with a gigantic diesel unit —the largest fuel-oil engine in the world.

The new steam plant adds eight 17,200- sq.ft., Stirling-type, 3-drum boilers operating at 365 lb. pressure and 752 deg. F. Had the question been one of an entirely new station it is probable that a higher pressure between 500 and 640 lb. would have been adopted. But, as Section 2 had been built for 355 lb., the economical advantage of the higher pressure was secondary to the desirability of coordinating the steam plants and turbines of the two sections. Each unit is designed for a normal evaporation of 106,000 lb. per hr., maximum continuous evaporation of 142,000 lb., and short-time peak load evaporation of 157,000 lb., when operating primarily on Scottish and Polish fines having calorific values ranging from 10,000 to 11,000 B.t.u. Water volume is 1,480 cu.ft., steam volume 425 cu.ft., furnace volume about 8,100 cu.ft. The superheater de-



H. C. Oersted station at night, showing new extension. Sections 1 and 2 are hidden behind the turbine house. The diesel plant is at extreme right; the switch house shows in front of the turbine house

Cylinder heads of the 8-cyl., 2-cycle, double-acting unit



livers steam at 720 to 780 deg. F., according to load.

Stoking is performed by twin-louvre chain traveling grates moving at ten controlled speeds. Guaranteed coal consumption is 26 to 40 lb. per sq.ft. at normal and peak loads, respectively, on a grate area of 530 sq.ft.

The economizer takes the form of horizontal return-bend-steel tubes of 6,160 sq.ft. heating surface. At normal boiler load, flue gas is cooled from 590 to 410 deg. F. and feedwater heated from 266 to 338 deg. F. In conjunction, the 18,700-sq.ft. tubular air heater heats combustion air from 68 to 248 deg. F. and cools flue gas from 410 to 248 deg. F. Cinder catchers, forced-draft fans, secondary grate fans and mechanical soot blowers serve each unit.

These boilers supply two 36,000-kw., 1,500-r.p.m., Parsons-type turbines with steam at 327 lb. and 743 deg. Steam is bled at 70 lb. and 9.4 lb. gage. At 25,000 kw. (most economical load), guaranteed heat consumption, including bleeder and condenser consumption, is 10,845 B.t.u. Each unit is used by two parallel 20,200-sq.ft. condensers cooled by seawater.

The alternator is a 3-phase, star-connected, 40,000-kva. 4-pole machine, voltage 6,500/6,000, 50 cycles.

### Diesel Engine

In conjunction with the steam plant is the world's largest diesel. It is an 8-cyl. double-acting, two-stroke-cycle motor with 33 in. bore, 59 in. stroke, operating at 115 r.p.m. Normal output is 12,500 kw.; at this load maximum efficiency is obtained and guaranteed fuel consumption is 0.53 lb. per net kw.-hr. Maximum continuous rating is 15,000 kw., with net fuel consumption of 0.44 per net kw.-hr.

The engine is designed for starting by air at 355 lb. pressure and reaches normal speed within $1\frac{3}{4}$ min. Fuel is injected under a pressure of 5,200-6,250 lb. through three atomizing valves at the top and three at the bottom of each cylinder, the valves being driven in the usual fashion by a special shaft coupled to the engine crankshaft through a chain drive. The pumps, two to each cylinder (one supplying the upper and the other the lower valves) are driven from a camshaft in like manner. Scavenging air is supplied by rotary blowers in connection with a large scavenging tank and is admitted midway on the cylinders under a pressure of 1.64 lb. per sq.in.

Cylinders are cooled with fresh water, the pistons with lubricating oil from the forced-lubrication system, and both fresh water and oil are cooled with sea water from the cooling water ducts.

The "Asea" 3-phase flywheel alternator is star-connected for a working voltage of 6,000/6,500 volts, maximum output 19,000 kva., 50 cycles.

The diesel-generator is not used continuously and was installed for stand-by and peak load purposes only. One of the features of a fuel-oil motor of this type is its extremely short starting period; it may take load immediately if a fault occurs in the steam plant. On the occasion of my visit to the plant, I timed a normal starting of the unit. It was brought up to full speed and synchronized in one minute and forty seconds, a considerable gain over the usual 30 to 60 minutes required to start up a turbine. A second feature that makes the machine admirably suited to stand-by purposes is that no fuel is required while standing-by, whereas the steam plant entails a considerable loss during banking periods. As the machine is fully staffed at all times, a small machine shop is installed in the diesel house where the men on watch can be employed on minor repairs during idle hours.

As regards the use of the diesel for peak-load pur-

poses, it is as yet impossible to furnish any definite data concerning its effect on station economy. The extension came into part operation in the fall of 1932 with one 36,000-kw. turbo-alternator and four boilers, while the second similar unit and the diesel were not placed in operation until the major part of the load came on during 1933. As the diesel came into operation during the same period, it is difficult to determine how much of the gain in economy is due to the new steam plant and how much to the diesel. However, a few facts of the operating combination may not be without interest.

### Diesel Takes Peak

The station is now so designed that the steam plants, section two and three, can arbitrarily combine to take the present maximum demands comfortably and economically, with the diesel taking the peak each day. It is accordingly being used this winter, as during the last, in regular schedule. It is started each day between 3 and 4 o'clock in the afternoon, the actual time depending upon the weather and the natural light conditions obtaining; the system reaches its peak between 5 and 6 o'clock and the diesel is taken out about 7 to 8 p.m. As a rule, it is not necessary to load it up to more than 8,000-10,000 kw., which is only about three-quarters of most economical load, but it can immediately be loaded up to its maximum of 15,000 kw. in case of trouble elsewhere. In this connection it is very interesting to note a recent experiment in which the diesel was run for a full four hours at maximum load with a *clear exhaust,* the test having followed immediately after a 4-hr. period at most economical load (12,500 kw.)

The inclusion of the diesel during these hours each day avoids carrying a banked boiler for reserve service during the peak and means a large saving in banking losses when the cost of carrying the banked boiler amounts to at least 5 to 6 tons of coal per day.

The consumption of fuel oil is 0.53 lb. per net kw.-hr. at most economical load of 12,500 kw. and 0.55 per net kw.-hr. at three-quarter load. Average daily consumption comes somewhat higher, say 0.60 to 0.62 lb. per net kw.-hr., the reason being the heavy starting and low average load. Fuel cost of the diesel plant amounts to about 1.5 ore per net kw.-hr. (including cost of lubricating oil) as against 1.0 to 1.1 ore per kw.-hr. for the steam plant, depending upon load factor. These figures, however, do not give the true picture, because the cost of peak-load diesel power should not be compared with the average cost for the steam station, but rather with the cost of producing the peak with steam equipment and including such items as banking losses and starting losses of boiler and turbine.

No statement has been made as to whether more diesels will be added to the existing section in the future. That cannot be considered until comprehensive data will have been gathered on the performance of the single motor and will depend of course on the future needs of the community and on the structural program then arranged by the Copenhagen Department of Light and Power in regard to the disposition of those future needs. The diesel building is, however, designed for extension to house as many as three more big diesels.

*Station designed and built by Technical Staff, Dep't. Light & Power, City of Copenhagen. Data checked by them.

# DOWN WENT HEATING COSTS

*By W. H. McCollum*
*Bozeman, Mont.*

TEN years passed between the taking of the two lines on each of the three charts here reproduced, ten years in which tremendous savings were made in the cost of heating steam. The plant was first fired up in January, 1923, and the first lines were drawn on the charts at the close of the same year, the second lines ten years later on a day when temperature coincided.

When installed, the plant was considered up to date for its size. It included two 3,750-sq.ft. Stirling boilers, Cochrane open feedwater heater and meter, S. C. feedwater regulators, Sturtevant turbine drive for the forced-draft fan, Bailey flowmeter and draft gages, and underfeed stokers. After eight months, the stokers were replaced by Coxe Type B traveling-grate stokers, which proved very satisfactory.

Pressure control was originally by a Mason regulator hooked to the fan-turbine throttle, but stoker speed and stack damper were controlled by hand. This required close watch, else the fire burned off short or put coal in the ashpit. Later, a ¾-in. line was run from the turbine throttle to the stoker engine and to a cylinder and plunger to operate the damper. Although quite temperamental, it was better than hand control. Other suggested improvements were turned down by the management because there seemed to be no money to buy even small pipe and fittings.

The damper-opener plunger operated in oil. Gland adjustment was difficult to maintain, so it either spilled oil or stuck tight and smoked us out. One fireman managed to get enough fittings to replace it with an old cylinder from a pressure regulator, with cup leathers for packing and a loop of pipe for a water seal. He also got enough chain to connect the return-tank float to the make-up water valve, preventing waste of water and avoiding our former running to the basement to regulate make-up by hand.

After nearly seven years of operation with only essential repairs, one of the firemen was made chief and was confronted with the task of rejuvenating the plant on a reduced budget.

We have about 1,900 ft. of 5-in. steam and return lines, 1,400 ft. of 3- and 4-in., and 1,700 ft. of 2- and $2\frac{1}{2}$-in. lines connecting eighteen buildings with about 73,000 sq.ft. of radiation. Variators installed at intervals of about 150 ft. formerly cared for expansion in the return lines. The copper diaphragms in most of them began to leak. As they were buried from 7 to 14 ft. in the ground, it was quite costly to dig them up and hard to determine just which ones were leaking. Finally we pulled out the whole bunch and replaced them with expansion joints in the same manholes where steam-line expansion joints were located, thus spacing them at intervals of 200 to 300 ft.

Later a new barrel for the water end, new valves, stems and springs were installed in the 14x20x24-in. vacuum pump that brings back condensate. We also connected a small receiving tank above the pump and bypassed part of the water through the pump continually to keep it from running dry. The pump formerly ran 90 to 120 strokes per min. After overhauling, and with return-line leaks stopped, it ran only 12 to 25 strokes per min., with vacuum increased from 6 to 10 in. We have also stopped using the condensate pump formerly required in one building.

Our feed pumps, two center-packed plunger units, hammered so badly they shook the feed lines and boiler water columns. We had already replaced two broken pump rods and all four water cylinders, which had been badly cracked. We put in an extra-heavy tee on the pump discharge, from it dropped a 4-in. pipe 6 ft. to the floor level, then made a U turn and put on a capped 22-ft. vertical length of 5-in. pipe for an air chamber. We now have no water hammer or air in the feedwater, and we haven't lost a rod since.

Recently, one boiler refused to take water. On taking the bonnet from the globe valve on the feed line, we found the valve had been put in backwards, with the result that the disk had come off the stem and closed tight.

Nearly all steam is used for heating, reduced from 140 to 60 lb. as it leaves the plant. Low-pressure steam sometimes fluctuated as much as 20 lb. in pressure, but after we repiped the control line on the low-pressure side of the reducing valve it gave no further trouble. Most of the radiator traps were blowing through too, so we have been replacing them and also trapping lines and headers to overcome water hammer.

We have reconstructed the reducing valve between steam and exhaust lines and rearranged the float valve feeding the header to get higher and more constant feedwater temperature.

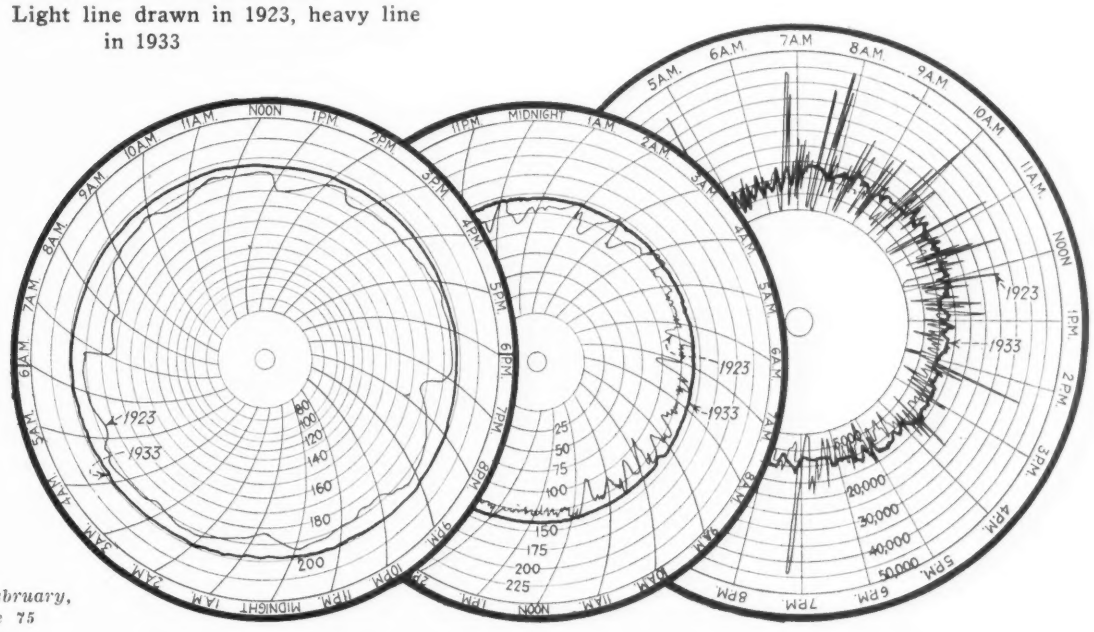
## Increased Load

During the ten years, buildings have been added, increasing radiation load about 10 per cent, but our load has remained the same because of the line repairs, improved trapping and repaired vacuum pump. Engineer's figures for the heating period Oct. 15, 1923-May 15, 1924, show steam cost of $0.60 per 1,000 lb. For the winter of 1932-33 cost was $0.40 a thousand, including all repairs to lines and radiators, also coal for banking fires during the summer.

Actual evaporation per pound of coal as fired has increased from 5.85 to 6.50, which is better than it looks, as load varies from 20 to 150 per cent rating for one boiler, and the evaporation figure includes the summer with its light load. Coal burned is screenings running about 10,500 B.t.u. Reduction in coal price per ton amounts to $0.046 per 1,000 lb. of steam, while labor reductions amount to $0.012. The rest of the saving is due to better evaporation, lower cost of supplies and lower costs of coal and ash handling—now done by one man. Most plant changes have been made by the chief and firemen on shift, so costs have been low. Work on lines and in the buildings is done in summer when steam demands are light.

Suggestions for plant improvement have been made by Chief Engineer Davis, C. G. Monroe and me, but to Monroe, who has since moved to Great Falls, Mont., must be given credit for many ingenious devices. We miss him.

**Feedwater temperature, boiler pressure, and total evaporation charted in December, 1923, and ten years later. Light line drawn in 1923, heavy line in 1933**



# It Ain't The Heat—

# IT'S THE HUMIDITY

*By R. B. Purdy**

*Associate Editor*

HAVE you ever smoked a dry cigar? Have you ever *tried* to smoke one with a cracked wrapper? The answer is too little moisture, in the first case because the cigar was stored in too dry a place; in the second place, because it was made in air that was too dry.

On the other hand, any one who has worked in a chemical plant knows that there are certain types of chemicals which must be made in a room from which moisture is practically excluded, otherwise they are spoiled in process.

This is probably the reason for man's early effort to control the amount of moisture in air—after all, modern man thinks much more of his pocketbook than he does of his personal comfort.

During the last few years, however, research men have found the combinations of temperature and humidity that give the same feeling of comfort. They found that the good old saw about "It ain't the heat, it's the humidity" has some real foundation, for warm air feels less hot with some of the moisture taken out, and cool air feels less cold if some moisture is put in.

## Saturation

Air cannot hold in mixture with it an unlimited weight of water vapor—if a certain point is passed the excess water comes out either as fog or water droplets. Further, the amount of water air can hold varies with the temperature. When at a given temperature air has mixed with it all of the water vapor it can hold, it is called *saturated*. It may have, however, considerably less than the maximum amount of water it can carry at a given temperature. The actual weight of water vapor contained in a pound of dry air is therefore referred to as *absolute humidity*. Some authorities, however, say that absolute humidity is the actual weight of water vapor per *cubic foot* of the mixture.

*Relative humidity*, a more familiar term frequently shortened to "humidity," is the ratio of the actual weight of water vapor in a cubic foot of the mixture of air and water to the weight of water vapor that the cubic foot could contain if saturated at the same temperature.

Humidity, whether it is relative or absolute, is usually determined with a wet-bulb thermometer. This is simply an ordinary thermometer which has a piece of wet silk fastened around its bulb. This thermometer is whirled rapidly in the air or held so that the air will blow over it. Some of the water in the silk is evaporated. This cools the rest of the water and the thermometer bulb. The speed with which the water evaporates, and consequently the amount of cooling of the bulb, depends upon how nearly saturated the air is. If the air already contains all the moisture it can hold none will be evaporated from the wet silk, and therefore the temperature shown by a wet-bulb thermometer and that shown by an ordinary thermometer will be the same. But when the moisture content of the air is anywhere below the saturation point, moisture will be taken from the silk and the wet-bulb temperature will be below dry-bulb temperature, and will give the differential from which the humidity can be figured. To avoid all this computation, however, charts have been drawn from which the relative humidity and the weight of water vapor per pound or per cubic foot of air can be read when both wet-bulb and dry-bulb temperatures are known.

When a mixture of air and water vapor is cooled, both the wet-bulb and dry-bulb temperatures decrease, but the wet-bulb temperature decreases at a slower rate, so that the difference between them gets smaller. The relative humidity of the air, however, increases until finally the air reaches a temperature below which some of the moisture will begin to condense out. At this point, called the *dew-point* temperature, the air is saturated and dry-bulb and wet-bulb temperatures are the same. This temperature does not change unless water vapor is added to or taken away from the mixture. Thus, if saturated air were heated without removing or adding water vapor, the dry-bulb and wet-bulb temperatures would increase, relative humidity would decrease, but dew-point would stay the same.

## Air Cooling

When air water-vapor mixtures are cooled, heat must be removed, not only to cool the air, but also to cool the water vapor. Of course, the heat required to lower the temperature of the superheated vapor in a pound of dry air is small compared to that required to reduce the temperature of the air, because of the relatively small weight of water vapor present. For example, let's see how much heat must be taken out to reduce 80-deg. air with a relative humidity of 70 per cent to its dew-point temperature, 69 deg. At this temperature and relative humidity the air mixture contains 107 grains (0.0152 lb.)† of water vapor per pound of dry air. The heat which must be taken out to cool the air is found by

*Second of a series. The first, "Tailor-made Weather," appeared in November, 1934.

†7000 grains per lb.

multiplying the drop in temperature by the specific heat of air and by the weight of air cooled. Since the specific heat of air is 0.24, the multiplication becomes:

$h = 11 \times 0.24 \times 1 = 2.64$ B.t.u. per lb. dry air.

The heat removed to cool the vapor is found in the same way, except that the weight and specific heat of the vapor must be used. Since the specific heat of the vapor is 0.45, the calculation becomes:

$$h_v = 11 \times 0.45 \times 0.0152 = 0.075 \text{ B.t.u.}$$

Total heat removed is $2.64 + 0.075 = 2.715$ B.t.u.

Further cooling below the dew-point causes some of the water to condense out. This requires a definite amount of heat (called latent heat) per unit of water vapor, and must be considered. It is, however, somewhat simpler and more exact to deal with the heat contained in the water vapor than with the latent heat. Heat content of low-pressure water vapor is easily found from the equation

$$H = w \times (1059.2 + 0.45\,t),$$

where $w$ is the weight of the vapor in pounds, and $t$ the dry-bulb temperature. To find the heat removed, if the air in the above example is cooled down to 45 deg., the first step is to find the weight of water in the air at the final temperature. Chart will show this to be 44 grains (0.00628 lb.) Cooling the air to this temperature has caused the condensation of $107 - 44 = 63$ grains (0.009 lb.) of water. Heat content of the water vapor at 69 deg. was $H_1 = 0.015\ (1059.2 + 0.45 \times 69) = 16.35$ B.t.u. Heat content of the water vapor at the final 45 deg. is only $H_2 = 0.00628\ (1059.2 + 0.45 \times 45) = 6.79$ B.t.u. The difference between these two figures, $16.35 - 6.79 = 9.56$ B.t.u. The condensed moisture takes away with it the heat of the liquid, so that the heat that a cooling medium must remove from the water vapor is 9.56 B.t.u. — the heat in the condensed vapor, or $9.56 - (0.009 \times 13) = 9.45$ B.t.u. To this, of course, must be added the heat taken from the pound of dry air, or $0.24\ (69 - 45) = 5.76$ B.t.u., making the total heat to be taken from air-water vapor mixture $9.45 + 5.76 = 15.21$ B.t.u. This calculation can be carried out with the chart.

If a current of air is passed through a spray of water that is being continuously recirculated, and to which heat is neither being added or removed, the temperature of the water will increase or decrease until the wet-bulb temperature of the entering air is reached. When this condition is achieved the air will leave the spray saturated with dry-bulb and wet-bulb temperature the same as the entering wet-bulb temperature, and no heat will be added to or taken away from the air mixture passing through the spray. This property of air water vapor mixture is used occasionally as a means of cooling air. The cooling, however, is limited because the dry-bulb temperature can be lowered to only the wet-bulb temperature, normally, a drop of 5 to 15 deg.

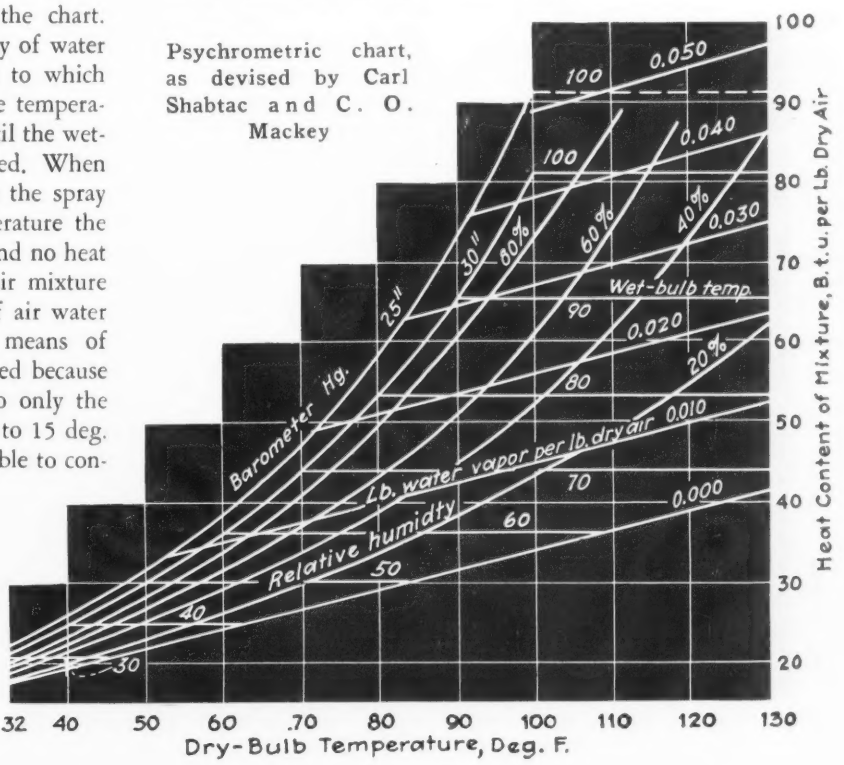
In air-conditioning for comfort it is desirable to control absolute humidity so that the relative humidity at the final room dry-bulb temperature is about 40 per cent. Thus, for example, if the room is to be kept at 75 deg. and 40 per cent relative humidity, the supply air must contain 52 grains of water vapor per pound, and the dew-point temperature must be 48 deg., assuming, of course, that moisture is not added in the room.

Water sprays offer an easy way to control absolute humidity and dew-point of supply air. If enough sprays are provided and water is cooled or heated, the air will leave saturated and with a dew-point and wet-bulb temperature almost the same as the temperature of the water spray. Thus, it is only necessary to control the spray water temperature in order to regulate humidity of a given air-conditioned space.

In summer it is primarily necessary to cool spray water. This is usually done by mixing refrigerated water with the water recirculated. In the winter the water must be heated instead, and this can be done by installing coils in the basin or tank below the spray. However, heating in this way is likely to cause odor. The same results can be obtained by heating the air and recirculating spray water without heating or cooling.

To figure out the proper dry-bulb temperature to which air going into the sprays must be heated to obtain the proper leaving dew-point temperature, it is necessary to remember only that when steady conditions are established there will be no heat added to or removed from the air as it passes through this spray. Therefore, leaving and entering wet-bulb temperatures will be the same. If, for example, air leaving the spray is to have a wet-bulb and dew-point temperature of 45 deg., the temperatures to which the air incoming must be heated may be found by following across the 45-deg. wet-bulb temperature line on the chart below until the moisture content of the entering air is reached. The dry bulb temperature at this point is the temperature to which the air should be heated.

For example, assume entering air at 30 deg. with relative humidity of 20 per cent. It contains about .0007 lb. of water vapor per pound of dry air. Following across the 45-deg. wet-bulb line to the .0007 lb. moisture line we find the dry-bulb temperature to which the air should be heated to be 71 deg.



# PRIME MOVER OF THE FUTURE?

# THE COMBUSTION TURBINE

*By William E. Trumpler*

*Mechanical Engineer*

**The combustion turbine, once deemed economically impracticable, demands new consideration in the light of today's higher turbine and compressor efficiencies and the ability of modern turbine blades to withstand high temperatures. Discussion of Mr. Trumpler's proposal will be welcomed.**

SO FAR the results with experimental combustion turbines have not been encouraging, and the general belief exists that there is little or no hope for them commercially. My purpose here is to show that summary conclusions can easily be wrong, and that there is a definite future for the combustion turbine, considering only established facts, not possible developments.

Before describing the specific solution of the combustion turbine referred to, it appears desirable to mention briefly the two principal working cycles: the constant volume and the constant pressure cycles diagrammatically shown in Figs. 1 and 2. In both diagrams, line *A-B* represents the compression of air and fuel, *B-C* the change caused by combustion, *C-D* expansion of the heated gas, and *D-A* exhaust of the expanded gas. The area *ABCDA* represents the work each of the cycles can theoretically convert into mechanical power.

It is clearly indicated that the first cycle, under similar conditions, delivers more power than the second. It is therefore not surprising that practically all combustion engines and most gas-turbine schemes are based on Cycle 1. While Cycle 1 represents the natural application for the piston-type motor, Cycle 2 is better adapted to the turbine motor. Cycle 1 is by nature intermittent, Cycle 2 continuous.

The continuous cycle favors the turbine, permitting high compression and expansion efficiencies. Continuous combustion as applied to Cycle 2 is more efficient than intermittent (explosion) combustion of Cycle 1. Cheaper fuels can be effectively utilized with continuous combustion than with the explosion type combustion. Recovery of the exhaust heat can be effected in turbines of either cycle, but not in engines where the expansion stroke follows immediately after the compression stroke. In systems of relatively low compression ratio, exhaust temperature is always materially higher than the end temperature of compression, and a material improvement can be obtained in the thermal efficiency.

The turbine is at a disadvantage in its combined mechanical and hydraulic efficiency in comparison with the piston engine. Further, cylinder and piston can be cooled effectively, permitting high compression ratios and combustion temperatures, while cooling in the turbine is either very difficult and impractical when applied to the rotor directly, or involves material loss of thermal efficiency if the gases are cooled by water injection.[1] To make the combustion turbine practical and safe from deterioration, the temperatures of combustion must be kept down to such a figure that the expanding gases, while passing through the rotor channels, do not exceed the temperature which the material can endure.

Since recent developments in steam turbine plants have made it possible to use steam with total temperatures up to 900 deg. F., one of the greatest obstacles for the combustion turbine has been removed. The way has further been paved by the gradual improvement of turbine efficiency as well as the development of air preheaters.

The arrangement which promises the most satisfactory solution of the combustion turbine is the constant-pressure cycle with regeneration of the exhaust heat. In Fig. 3 this arrangement is shown diagrammatically. The compressor is coupled directly to the turbine. Preheater and burner are interposed between compressor and turbine. The driven machine (generator) is also coupled to the turbine.

The cycle operates as follows: (1) Cool air enters the compressor at *A*. (2) It leaves the compressor at *B* with the full compression pressure and slightly heated by the compression; and enters one passage of the preheater. (3) While passing through preheater it is heated nearly to turbine exhaust temperature. (4) The air leaves preheater at *C* to enter the burner, where fuel is injected at *D* and burned with a continuous flame. (5) The fully heated combustion gas enters the turbine at *E*, expands through nozzles and wheel, imparting power to shaft. (6) The partly cooled gas at practically atmospheric pressure leaves turbine at *F* and enters the second passage of the preheater, running counterflow to the first passage. (7) After giving up most of its heat to the compressed air, exhaust leaves preheater at *G* at a temperature slightly higher than that of the air at the end of compression.

By recovery of the exhaust heat the fuel has to furnish little more heat than that converted into mechanical work in the turbine. The work of the compressor, however, must be covered by the turbine, and only the balance of the power will be delivered to the electric generator.

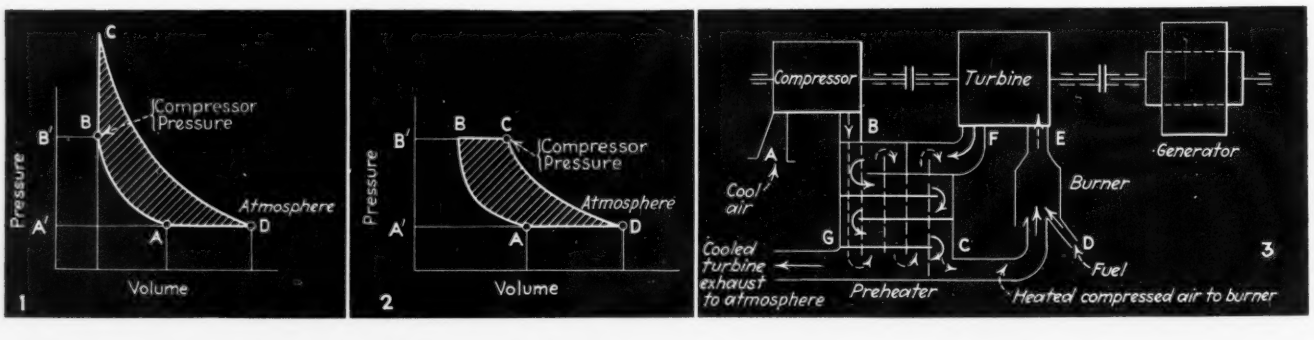
### Excess Power

Judging from the above description of the working cycle, the turbine must at all times develop more power than is required to drive the compressor. To this end certain conditions must be fulfilled, referring particularly to combustion temperature and turbine and compressor efficiency.

If $Hp_t$ denotes the power developed by

[1] "Gas Turbines" by L. S. Marks & Danislov, ASME Transactions 1924.

**Fig. 1—Constant-volume cycle. Fig. 2—Constant-pressure cycle. Fig. 3—Arrangement of elements**



the turbine and $Hp_c$ the power absorbed by the compressor, the ratio $\frac{Hp_t}{Hp_c}$ can be called the excess ratio of turbine over compressor power, or just "Excess ratio." This excess ratio can be expressed by the following formula:[2]

$$Exc.\ Ratio = \frac{Hp_t}{Hp_c} = E_t . E_c \frac{T_t}{T_c} > 1 \quad (1)$$

$E_t$, $E_c$—Turbine and compressor efficiencies
$T_t$, $T_c$—Absolute temperatures, adiabatic turbine exhaust, and at the entrance to compressor.

To make the excess ratio as large as possible, both compressor and turbine efficiencies must be as near to unity as possible, combustion temperature high, and entrance air temperature as low as possible.

There is a considerable variety of opinion as to possible maximum values of turbine and compressor efficiency. While in centrifugal compressors an efficiency of 75 to 80 per cent adiabatic can be counted upon, turbine efficiency depends to a great extent on pressure drop. With favorable proportions, and a pressure drop not producing too high a speed ratio, efficiency can rise to 85 per cent. The higher the speed ratio, the lower the efficiency. These values are likely to be surpassed if the demand for such machines makes research and development along this line commercially desirable.

In the matter of the temperatures that can be employed, the lower temperature is more or less determined by the atmospheric or climatic conditions. The combustion temperature must be so limited that, after expansion in the nozzle, the wheel is not subjected to a higher temperature than 850 deg. F., a temperature which can be endured continuously by modern high-grade alloy steels.

To give an idea of the excess ratios that can be obtained, Table I tabulates excess ratios for efficiencies ranging from 70 to 90 per cent, air intake temperatures from 0 deg. to 60 deg. F. (460 to 520 deg. F. abs.) and adiabatic turbine exhaust temperatures from 800 to 900 deg. F. (1,260 to 1,360 deg. F. abs.). To simplify this tabulation turbine and compressor efficiencies are assumed to be alike.

The values of Table 2 indicate clearly the large influence of low compressor intake temperatures and high turbine exhaust temperature, as well as high turbine and compressor efficiencies. Considering a turbine and compressor efficiency of 82.5 per cent, an air temperature of 30 deg. F. and a turbine wheel temperature of 850 deg. F., an excess ratio of 1.81 is obtained, which represents a practical value. Lower efficiencies reduce the excess ratio rapidly, while higher efficiencies produce comparatively smaller improvements. Cold climatic conditions, or winter operation produce large improvement in the excess ratio. Inasmuch as the excess ratio is affected by efficiencies and temperatures, it is independent of the compression ratio and the recovery of exhaust heat.

To materialize the conditions for a high excess ratio, it appears best to keep the compression ratio low. With low compression ratio, both compressor and turbine efficiencies can easily be made high. Also the temperature ratio will be favorable, as a low peripheral velocity means low stress, which in turn allows a higher wheel temperature. A minimum compression ratio, however, is of no economic value, since it leads to high-priced equipment. The compression ratio, therefore, is subject to compromise and must be taken as high as the various factors involved will permit. While no limitations are attached to the compressor, the turbine is limited by the maximum temperature of the gases at the wheel, the peripheral velocity as defined by the strength of the material, and the efficiency determined by the ratio of nozzle velocity to peripheral velocity.

To keep the temperature ratio high, it is essential to expand the gases as completely as possible before they enter the wheel channels. Multi-staging of the turbine, therefore, is out of question. Peripheral velocity of the wheel naturally is affected by the temperature, which experience limits to to about 850 deg. F., and cannot be assumed to be above 800 ft. per sec. For a single wheel, the relation of speed-ratio, peripheral velocity, efficiency and compression ratios are shown in Table II. The efficiencies are determined in the same way as for turbines operating on superheated steam.

### Total Thermal Efficiency

It is essential now to determine the total thermal efficiency of the unit, particularly for the speed ratios mentioned in Table II. In combustion turbines operating at moderate temperatures and with regeneration of exhaust heat, the percentage of combustion products in the exhaust gases is low, so that the change in specific heat can be neglected. For simplicity's sake, the slight increase of weight of the expansion gases resulting from the addition of fuel will be neglected too. It is assumed that all the compression work is converted into visible heat, and the heat loss caused by the expansion is all converted into work.

The following equation will then hold true for the total thermal efficiency ($E_{tot}$) without regeneration:

$$E_{tot} = \frac{(T_3 - T_4) - (T_2 - T_1)}{T_3 - T_2} \quad (2)$$

where $T_1$, $T_2$, $T_3$ and $T_4$ are absolute temperatures, respectively at the entrance to the compressor, compressor exit, temperature after combustion and at exhaust.

With regeneration, denoting the temperature loss in preheater by $dT$, the equation reads:

## TABLE I—EXCESS RATIOS

| $T_c$ abs. deg. F. | $T_t$ | Ratio $T_t$ to $T_c$ | Turbine and Compressor Efficiencies 0.70 | 0.75 | 0.80 | 0.825 | 0.85 | 0.875 | |
|---|---|---|---|---|---|---|---|---|---|
| 520 | 1260 | 2.43 | 1.19 | 1.37 | 1.55 | 1.65 | 1.76 | 1.86 | 1 |
| | 1310 | 2.52 | 1.23 | 1.42 | 1.61 | 1.71 | 1.82 | 1.93 | 2 |
| | 1360 | 2.62 | 1.28 | 1.47 | 1.67 | 1.77 | 1.89 | 2.00 | 2 |
| 490 | 1260 | 2.57 | 1.26 | 1.45 | 1.64 | 1.74 | 1.86 | 1.97 | 2 |
| | 1310 | 2.67 | 1.31 | 1.51 | 1.70 | 1.81 | 1.93 | 2.05 | 2 |
| | 1360 | 2.78 | 1.36 | 1.56 | 1.77 | 1.88 | 2.00 | 2.12 | 2 |
| 460 | 1260 | 2.74 | 1.34 | 1.55 | 1.75 | 1.86 | 1.99 | 2.11 | 2 |
| | 1310 | 2.85 | 1.40 | 1.60 | 1.82 | 1.94 | 2.07 | 2.18 | 2 |
| | 1360 | 2.96 | 1.45 | 1.66 | 1.89 | 2.02 | 2.15 | 2.27 | 2 |

## TABLE II—VELOCITIES, EFFICIENCIES AND COMPRESSION RATIOS

| Speed Ratio | Nozzle Vel. with periph. vel. 800 Ft./Sec. | Turbine Efficiency (see note) | COMPRESSION RATIOS for exhaust temperatures of 800 deg. | 850 deg. | 900 deg. |
|---|---|---|---|---|---|
| 1.80 | 1440 | 0.850 | 1.58 | 1.55 | 1.53 |
| 2.00 | 1600 | 0.825 | 1.74 | 1.71 | 1.68 |
| 2.20 | 1760 | 0.802 | 1.94 | 1.89 | 1.86 |
| 2.40 | 1920 | 0.786 | 2.19 | 2.13 | 2.08 |
| 2.60 | 2080 | 0.770 | 2.51 | 2.44 | 2.37 |

*Note*: Turbine efficiency is calculated on the basis of 0.96 and 0.86 nozzle and relative velocity coefficient. Ratio of inside to outside diameter (for radial-flow wheel), 0.65; recovery of exit velocity in diffuser, 0.65; windage and leakage losses 3 per cent.

## TABLE III—TOTAL EFFICIENCIES
### for Conditions Easily Obtainable

*Assumptions*: 20,000 c.f.m. compressor intake volume at 14.7 lb. abs. and 60 deg. F. Peripheral velocity of turbine wheel 800 ft. per sec.—Wheel exhaust temperature 850 deg. Air temperature after preheating 700 deg. (temp. loss 150 deg.)

| Speed ratio, turbine | Compression gage press. lb./sq.in. | Turbine Efficiency % | Turbine Hp. | Adiabatic Compres. eff. % | Hp. Compressor | Temp. after combustion, deg. F. | Useful temp. drop, deg. F. | Temp. rise combustion, deg. F. | Heat developed B.t.u.'s | Shaft Hp. of unit | Total thermal eff., % | Estimated Cost of unit | Estimated Cost per Hp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.8 | 8.10 | 80.0 | 1188 | 78.0 | 772 | 990 | 140 | 290 | 870 | 416 | 16.9 | $25,000 | $60 |
| 2.0 | 10.5 | 77.5 | 1420 | 78.0 | 960 | 1015 | 165 | 315 | 945 | 460 | 17.1 | ..... | ... |
| 2.2 | 13.2 | 75.5 | 1674 | 79.0 | 1144 | 1043 | 193 | 343 | 1028 | 530 | 17.8 | ..... | ... |
| 2.4 | 16.7 | 74.0 | 1956 | 80.0 | 1365 | 1075 | 225 | 375 | 1124 | 591 | 18.0 | ..... | ... |
| 2.6 | 21.2 | 72.5 | 2242 | 81.0 | 1620 | 1110 | 260 | 410 | 1230 | 622 | 18.1 | 30,000 | 48 |

## TABLE IV—TOTAL EFFICIENCIES
### for Most Favorable Conditions

*Assumptions*: Same as Table III, except air temp. after preheating 750 deg. (temp. loss 100 deg.)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.8 | 8.1 | 85.0 | 1430 | 80.0 | 752 | 996 | 146 | 246 | 1680 | 678 | 28.2 | $30,000 | $45 |
| 2.0 | 10.5 | 82.5 | 1710 | 80.0 | 935 | 1024 | 174 | 274 | 1870 | 775 | 28.6 | ..... | ... |
| 2.2 | 13.2 | 80.2 | 2010 | 81.0 | 1117 | 1055 | 205 | 305 | 2080 | 893 | 29.7 | ..... | ... |
| 2.4 | 16.7 | 78.6 | 2340 | 82.0 | 1330 | 1089 | 239 | 339 | 2310 | 1010 | 30.5 | ..... | ... |
| 2.6 | 21.2 | 77.0 | 2690 | 83.0 | 1580 | 1125 | 275 | 375 | 2554 | 1110 | 30.0 | ..... | ... |
| 2.8 | 26.5 | 75.0 | 3020 | 83.0 | 1860 | 1160 | 310 | 410 | 2790 | 1160 | 29.3 | 35,000 | 30 |

[2]See Gas Turbines by L. S. Marks & Danislov, ASME Transactions, 1924.

$$E_{tot} = \frac{(T_3 - T_4) - (T_2 - T_1)}{T_3 - (T_4 - dT)} \qquad (3)$$

In Tables III and IV the total efficiencies are computed for compression ratios taken from Table II. In Table III over-all efficiencies are shown for average temperature conditions and moderate compressor or turbine efficiencies, while in Table IV the best known temperature and efficiency assumptions are made. In both tables the power developed by a unit designed for 20,000 cu.ft. per min. air at the compressor intake is computed, also an approximate cost for the complete unit. Total efficiencies of about 20 per cent are obtained in Table III and slightly over 30 per cent in Table IV. Even with speed ratios of 2.8 at the turbine wheel, there is no drop in total efficiency or increase in cost per horsepower developed. These figures compare favorably with those of steam and oil engine plants.

### Arrangement

The principal parts of the combustion turbine are the compressor and the turbine, preferably direct coupled, as shown in Fig. 3. The compressor is of the multistage centrifugal type, water-cooled to obtain the most favorable performance. In design of this compressor, attention should be directed only to obtaining maximum efficiency at the operating point, and not to flat pressure characteristic. Since the nozzle area at the turbine is constant, only slight variation of the air volume will take place. This will be the case even at reduced load, and high efficiency of the compressor at all loads is obtained.

The most critical part is the turbine wheel. It has to operate at the highest possible temperature, maintain high peripheral velocity, and be of a design consistent with high efficiency. A radial reaction wheel will satisfy the above conditions best. It will be surrounded by a volute-shaped nozzle of double-wall construction, the inner wall being insulated from the outer, which, being cooler, relieves the inner one from pressure stresses. The wheel is preferably overhung, and exhausts axially into a diffuser wherein a large fraction of the exit velocity is converted into pressure.

### Air Preheater

Regeneration of the exhaust heat is best accomplished in air preheaters like those now employed in boiler installations. To transfer the heat from the exhaust gases to the compressed air, a temperature drop of about 150 deg. F. is required. Smaller temperature drops are possible, but lead to excessively large and expensive apparatus. Too large a preheater causes an increased pressure drop and difficulty in regulation, as will be explained later.

Operating on the counterflow principle, a preheater is preferably of the tubular type, and will require only 5 to 8 in. water-pressure drop in each passage, a loss which is less than 2 per cent on the compresor or turbine. The preheater must be well insulated to prevent heat losses.

A few words may be said about the burner, since a few novel features are involved. With the exhaust temperature of the turbine kept at 850 deg., the compressed air will be supplied to the burner from the preheater at 700 deg. The burner, therefore, has to supply comparatively little heat as the temperature to be reached in the burner must not exceed 1,100 to 1,150 deg. Since no flame can be maintained at a temperature of less than 1,600 deg., a special burner must be used. To permit a richer mixture and consequent higher flame temperature, only part of the air flow will be used in the burner, and the combustion gases mixed with the rest of the air to produce the desired temperature of the mixture.

Operation of the burner differs from the usual ones also in that the pressure is above atmospheric, which requires special provisions for ignition. To keep its size within reasonable limits, a comparatively high velocity must be maintained at the throat of the burner and special features are necessary to retain the flame there. While theoretically any fuel could be employed, only gases and heavy oils should be considered for the present.

### Starting and Regulation

The combustion turbine, like the reciprocating motor, requires an outside source of power to start from rest.

There are two methods for starting a combustion turbine of the type described here. First is a small motor driving the main shaft to a slow rotation, so that air is brought into circulation and the burner can be ignited. When the flame is established, at almost atmospheric pressure, the unit will gradually accelerate by its own power, until normal operation is reached.

The second method requires a power-driven fan, blowing air into the compressor intake, bringing about slow rotation of the shaft and considerable air circulation. This second method requires no mechanical connection to the shaft, and permits a better start of the burner and more powerful acceleration of the unit.

During the starting period, the burner does not receive preheated air, as the preheater lags considerably behind, and the fuel mixture must be made richer to obtain the desired combustion temperature. When shutting down, it is desirable to keep the machine in rotation for a while with the fuel shut off.

To regulate the unit for a varying demand of power at constant speed, it is necessary to use a temporary quick-acting element superimposed on a slow permanent change. The first is a change of combustion temperature, the second a change of compression. A sudden drop in load may require blowing off compressed air, to prevent a reduction of the flame temperature below the minimum necessary to keep the burner going.

The difficulty with regulation lies primarily in the large receiver capacity of the preheater. Raising the pressure at the compressor will ultimately increase the power of the unit, but for a quick increase will have the opposite effect. The load at the compressor is increased, while the power at the turbine remains the same. It is, therefore, necessary temporarily to raise the combustion temperature to get increased power. Compression will be gradually increased, so that the temperature can be lowered to the former safe value. Adjustment of the compression ratio can be obtained by movable guide vanes at the compressor without sacrificing performance. When the load drops, the temperature must be lowered immediately, and possibly air blown off, until the correspondingly lower compression ratio has been gradually established.

Regulation in general is rather difficult when frequent and sudden changes occur, and a lower average temperature must be assumed to prevent overheating of the turbine wheel. To insure the best possible regulation, the receiver capacity of the connecting passages between compressor and turbine through the preheater and burner must be kept to a minimum.

It has already been shown in the figures of Tables 3 and 4 that the proposed combustion turbine can compare with steam and oil engine plants. Its application, however, is most desirable in unit sizes below 10,000 hp. It is very advantageous in cold climates, and where water is scrace. While suitable as a power-house prime mover, it is particularly adapted to variable-speed drive for centrifugal pump or booster in gas distribution systems. As a standby unit to be used mostly in the cold season, it is more desirable than a steam unit, as it requires little attention when standing idle. In comparison with oil engines, it operates with less vibration, is easier to operate and lower in first cost.

### Possibility of Future Improvements

This outline of a combustion turbine would be incomplete without indicating the way to future improvements. The figures presented on performance and approximate costs are mostly based on assumptions dictated by the present state of the art. Considerable improvements are likely to come in the hydraulic performance of turbines and compressors, also in alloy steels suitable for higher temperatures. Even small improvements in these two directions will, as has been stated before, result in quite material improvement of the total efficiency.

A factor which may help to improve conditions for the turbine, is over-expansion at the turbine wheel to reduce the temperature of the gases while passing through the blade channels. While such a condition has been observed, little is known of its usefulness. Should over-expansion prove feasible without appreciable losses it would permit the use of a higher combustion temperature under otherwise similar conditions.

Should it be possible to reduce the temperature loss in the preheater from 150 deg. to below 100 deg. without increase of size or pressure drop, a further improvement is to be recorded. Experiments indicate that this is to be expected in the near future.

Considering the various features as outlined above, particularly simplicity of construction, low first cost, and economy of operation, the combustion turbine deserves today the serious consideration of builders of thermal prime movers.

# PIPING – BASIC INFORMATION

**PIPING, common denominator of the power services, ties together all power-generating elements. 5 to 10 per cent of the total investment in power, it is perhaps the greatest worry when poorly laid out and badly maintained. To serve as a general introduction and compendium of basic practical information on piping, POWER presents the following 13 pages compiled by R. B. Purdy and E. J. Tangerman, Associate Editors, with the assistance of a number of authorities in the field.**

PRECEDING selection of the most suitable type of piping material must be a knowledge of conditions to which the piping system will be subjected. Severity of fabrication, corrosive conditions, temperatures, pressures, ease of replacement, importance of lost or delayed production, temporary or permanent installation —all have a bearing.

Steel, wrought iron, copper, brass, and cast iron are the principal power piping materials. Each is produced with variations in chemical composition and manufacturing procedure to meet specific conditions of service, such as strength, ductility or corrosion resistance.

SEAMLESS STEEL PIPE—Most high-pressure piping in power plants is seamless steel, made in sizes up to $5\frac{1}{2}$ in. by the piercing process, sizes $5\frac{1}{2}$ to $9\frac{1}{4}$ in. by either piercing or cupping, sizes above $9\frac{1}{4}$ in. by cupping. Seamless pipe is normally low-carbon steel, but for high-temperature or other special services, it may be high-carbon steel, 4-6% chrome, 11-14% chrome, 16-20% chrome, 18-8 (18% chrome, 8% nickel), chrome-tungsten, or various other combinations.

RESISTANCE-WELDED STEEL PIPE—Introduced within the last year or two in the same range of materials and sizes as seamless steel and for similar service.

WELDED STEEL PIPE—Welded steel pipe in sizes up to $1\frac{1}{4}$ in. is made by the butt-weld process, sizes $1\frac{1}{4}$ to 3 in. are either butt-weld or lap-weld, sizes 3 to 24 in. lap-weld, sizes 20 to 30 in. either lap-weld or hammer-weld, sizes above 30 in. hammer-weld.

WROUGHT-IRON PIPE—Wrought-iron pipe in sizes up to $1\frac{1}{4}$ in. is made by the butt-weld process, sizes $1\frac{1}{4}$ to 2 in. by either butt-weld lap-weld, sizes 2 to 14 in. by lap-weld, and sizes 14 to 24 in. by either lap-weld or hammer-weld. Larger sizes are either hammer-welded or fusion-welded.

COPPER AND BRASS PIPE—Copper and brass pipe are seamless cold-drawn in sizes up to 12 in. O.D., with standard wall thickness in sizes to 4 in. (thickness in larger sizes is usually to specification). Thin-walled tubing is also available in sizes to 6 in. O.D., connected by flared or soldered couplings. Three brass-type alloys are also available, red brass (85% Cu—15% Zn), yellow brass (67% Cu—33% Zn), muntz metal (60% Cu—40% Zn). The Government specifies No. 1 for hard service, No. 2 for less-hard service; No. 3 is not good for water piping.

CAST-IRON PIPE—Cast-iron pipe, as the name implies, is cast in sizes 1 to 72 in. It is available in smaller sizes with threaded ends conforming to steel and wrought-iron pipe dimensions, also in a range of sizes with flanged, bell-and-spigot, and plain ends.

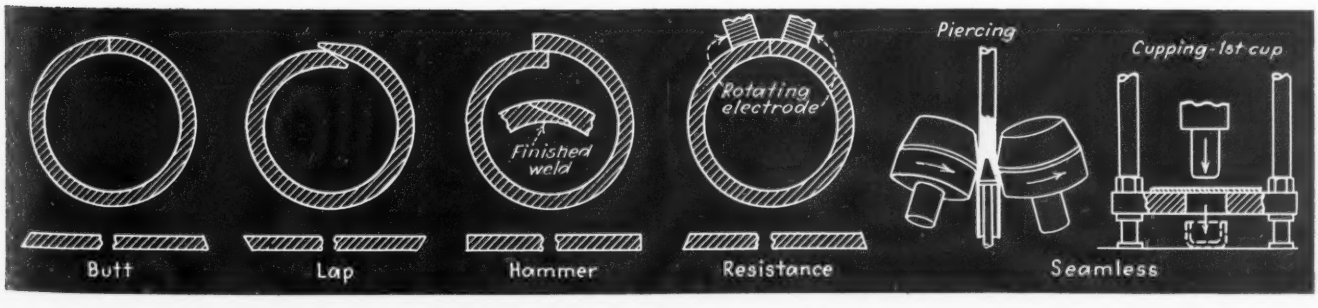
SPECIAL TUBULAR PRODUCTS—Tubular products are also available in a variety of materials other than those previously discussed, for example, aluminum, aluminum alloys, Monel metal, Admiralty metal, stainless steel, asbestos, fibre, rubber, lead, glass, wood, and tile. Some of these piping materials are unknown in power plant systems, while others are used extensively but are confined to specialized services or particular equipment.

## Manufacturing Methods

BUTT-WELD PROCESS—Strip steel or wrought iron, called "skelp," is rolled to a specified length, width, and gage, with edges beveled. This is curled into a tube with mating edges which are hot enough so that die pressure welds the joint. Two sets of rolls then size, descale and straighten the pipe. Used for low-pressure services, weld efficiency being about 70%.

LAP-WELD PROCESS—Skelp is heated, its edges scarfed, and it is passed through a ring die (or rolls in larger sizes) which forms it into a cylinder with overlapping edges. Semi-circular rolls force the scarfed edges together, weld them over a mandrel, and roll the weld to normal pipe thickness. The pipe is then sized.

**Typical pipe types, showing form of material**



descaled and straightened. Permitted by Pressure Piping Code up to 400 lb. pressure at temperatures to 750 deg. F. Weld efficiency 90%.

HAMMER - WELDING—Used on large sizes. A flat plate is rolled as in tank manufacture to a cylinder with overlapping edges. A short section of edge is heated and welded at a time. The finished weld is hammered to plate thickness, then the pipe is annealed, sized, straightened and descaled. Weld efficiency 90 to 95%.

RESISTANCE WELDING—Rolled skelp is formed into a cylinder which is passed between rolls with a pair of large-diameter copper rolling welding electrodes just ahead. Abutting edges are welded, then pipe is rolled to size and straightened. Weld efficiency equivalent to pipe wall or 100%.

SEAMLESS—Steel bars with centers marked are heated almost white hot, then forced between rolls revolving in the same direction and skewed. They produce a crack at the center which is forced over a mandrel to form a rough cylinder without a seam. This is smoothed up, descaled, and rolled to size, making *hot-finished* seamless pipe. *Cold-drawn* pipe is similarly made, except that sizing is done by drawing a tube cold through rolls.

The cupping process begins with a flat circular plate punched to a rough cup. Subsequent heatings and punchings elongate the tube, reduce diameter and wall thickness. The cup is then cut off the end, the pipe annealed, rolled and descaled.

FUSION-WELDING—The plate is rolled to a cylinder and the abutting edges welded with an electric arc or oxy-acetylene torch. This method is usually limited to large-diameter pipe or for very heavy gages.

FORGED PIPE—Forged pipe is used occasionally for exceptionally difficult services, particularly under terrific hydraulic pressures. It is made by forging a blank of the desired size and shape, then boring and turning. Flanges or outlets are machined from solid.

To the initial cost of pipe must be added transportation, fabrication, erection, fittings, and overhead. Amortization and maintenance must also be considered to determine which type of pipe will cost least during the useful life of the system. The cost comparison of commonly used piping materials as given below will form a starting point, provided proper consideration is given to the other factors already enumerated.

**Recommended Gasket Materials**

| luid Conveyed | Service | Gasket Material |
|---|---|---|
| TEAM (Also Boiler Blowoff) | Exhaust | Comp. asbestos |
| | Saturated | Comp. asbestos or corrug. copper |
| | Superheated—up to 600 deg. F. | Comp. asbes., corrug. Monel or soft steel |
| | Superheated—over 600 deg. F. | Soft steel, Monel or silver (thin) |
| ATER | Boiler feed | Comp. asbes., corr. copper or Monel |
| | Hydraulic | Hard fiber |
| | Cold-circulating | Cloth inserted or red rubber |
| | Suction and discharge | Red rubber or oiled paper |
| | Service, city and fire (small) | Red rubber |
| | Hot | Comp. asbestos |
| ILS | Heavy cold | Paper or comp. asbestos |
| | Light—gasoline, kerosene | Asbestos impreg. with graphite, paper, bakelite |
| | Benzol | Composition asbestos |
| IR AND GAS | Hot | Composition asbestos |
| | Cold | Comp. asbestos, red rubber |
| MMONIA | Hot | Thin asbestos |
| | Cold | Sheet lead |
| CIDS | | Sheet lead or alloy steel |
| RINE | | Red rubber |

(Base 2-in. p.s.—open-hearth steel as 1)

| | |
|---|---|
| Open-hearth Steel Pipe (Threaded and Coupled) | 1.0 |
| Seamless Steel Pipe (Threaded and Coupled) | 1.1 |
| Wrought Iron Pipe (Threaded and Coupled) | 1.7 |
| Brass Pipe (Plain Ends) | 3.9 |
| Copper Pipe (Plain Ends) | 4.0 |
| Cast Iron Pipe (Threads Only) | 1.6 |

In any power plant piping system, several types of pipe may be required. Due to the many kinds of pipe, need for good specifications is apparent. Standard specifications preclude misunderstanding and save time. Specifications listed are those generally recognized by pipe manufacturers and fabricators. Copies are available from associations or pipe manufacturers.

**Principal Standard Pipe Specifications**

**Steel**

Std. Spec. for Welded and Seamless Steel Pipe (B36.1-1934) [A.S.T.M., A53-33]
Tent. Std. Spec. for Lap-Welded and Seamless Steel Pipe for High-Temp. Service (B36.3-1934) [A.S.T.M., A106-34T]
Tent. Std. Spec. for Elec. Fusion-Welded Steel Pipe, 30 in. and over (B36.4-1934) [A.S.T.M., A134-32T]
Tent. Std. Spec. for Elec. Resistance-Welded Steel Pipe (B36.5-1934) [A.S.T.M., A135-32T]
Tent. Std. Spec. for Forge-Welded Steel Pipe (B36.6-1934) [A.S.T.M., A136-34]
Tent. Std. Spec. for Lock-Bar Steel Pipe (B36.7-1934) [A.S.T.M., A137-34]
Tent. Std. Spec. for Riveted Steel & Wrought-Iron Pipe (B36.8-1934) [A.S.T.M., A138-34]
Tent. Std. Spec. for Elec. Fusion-Welded Steel Pipe, 8 to, but not inc., 30 in. (B36.9-1934) [A.S.T.M., A139-34T]
A.S.T.M. Spec. for Steel Suitable for Welding A151-33
Amer. Petroleum Institute Line Pipe Spec. Std. No. 5-L
Amer. Petroleum Institute Pipe Spec. Std. No. 5A

**Wrought Iron**

A.S.M.E. Boiler Code Spec. for Welded Wr. I. Pipe (Des. S-19)
A.S.A. Spec. for Welded Wrought Iron Pipe (B36.2-1934) [A.S.T.M., A72-33]
Fed. Spec. for Pipe; W.I., Welded, Black & Galv. (WW-P-441)
U. S. Navy Dept. Spec. for Pipe, Iron, Wrought (44-P-11c)
Amer. Ry. Ass'n., Mech. Div., Spec. for Welded W.I. Pipe
Amer. Petroleum Institute Stds. for Line Pipe (No. 5-L)
A.P.I. Stds. for Casing, Drill Pipe and Tubing (No. 5-A)
Amer. Stds. Ass'n. Spec. for Riveted Steel & W.I. Pipe (B36.8-1934) [A.S.T.M., A138-34]

**Flanges**

Amer. Std. for C.I. Flanged Fittings (B16b-2 for 25-lb., B16a for 125 lb., B166 for 250 lb.)
Amer. Std. for Steel Flanged Fittings and Companion Flanges (B16e-1932)
Amer. Std. for 800-lb. (Hydraulic) C.I. Flanged Fittings

**Bolting Materials**

A.S.T.M. Std. Spec. A96-27
Amer. Tent. Std. for Wrench-Head Bolts and Nuts and Wrench Openings

BOLT AND NUT MATERIALS—While the average flanged joint uses low-carbon steel or wrought iron bolts with square heads, for pressures over 160 lbs. and temperatures above 450 deg., they should be alloy steel, heat-treated, as in A.S.T.M. Specification A 96-31. This standard shows three classes, Class "C" for conditions over 400 lbs. gage and/or 600 deg. F. At high pressures and temperatures it is customary to replace the headed bolt with a stud threaded for its full length, carrying hexagonal nuts at both ends. There are also special bolt materials for heavy-duty or corrosives.

The usual nuts are mild carbon steel produced according to the American Standard for Heavy Semi-Finished Nuts B-18b, and are of the cold-punched, hexagonal type. With alloy bolts, semi-finished, chamfered and trimmed nuts made according to A.S.T.M. Specification A 96-31 should be used. The material for such nuts must not include more than 0.045% phosphorus for Class 1 (high-pressure) service. For temperatures above 750 deg., hot-forged, cold-trimmed nuts being used, with Nitralloy washers.

# —DESIGN AND LAYOUT

IF A piping designer were concerned only with the primary purpose of piping—transportation of a fluid from here to there—his job would be easy. But he must consider many other factors, and these become at times both difficult and important. Too often, for example, ease of operation and appearance are overlooked in the effort to design the least costly piping system consistent with safety, reliability and operating flexibility.

The starting point in the design of any system of piping, whether for main or auxiliary steam lines, heating systems, boiler feed, condensate or service water, should be a line diagram showing all equipment to be connected and all valves required. Right here, operating flexibility must be considered and balanced against its cost. One must here decide whether to provide a double or loop header arranged so that maintenance can be carried out without interfering with general plant operation, or a single-header system arranged to that any small repair means a major shutdown.

Between these extremes is a middle course which yields an economical, yet sufficiently flexible and reliable, system. The tendency is toward greater simplicity and a corresponding willingness to face the possibility of a partial shutdown in case valve or pipe maintenance becomes necessary. This perhaps is an outgrowth of the better and more reliable valves, pipe, joints and fittings now available.

In making up these diagrams don't overlook future plant additions; arrange the piping for easy extension to serve new equipment.

The next job is to determine the pipe sizes and weight of pipe. For all ordinary service conditions the dimensions of flanges, fittings and pipe have been standardized. American standards exist for 125-lb. and 250-lb. cast-iron fittings, and tentative American Standards for steel fittings and A.S.T.M. specifications 106-33T for seamless steel pipe for 250-, 400-, 600-, 900- and 1,500-lb. steam pressures at 750 deg. F. In general, these Standards are fully equal to the operating conditions for which they are rated. Thus, selection of pipe, flange and fitting dimensions is merely a simple choice of the proper standard.

Consider, however, the nature of service. For example, a pipeline carrying high-temperature steam that is to be cut in and out of service at frequent intervals should be of heavier pipe than would normally be selected. This is particularly true for small-sized pipe where screwed connections are used. In any sizeable job where different pressures and fluids are involved, it is worthwhile to make up a schedule of pipe, flange and fitting dimensions used in different services.

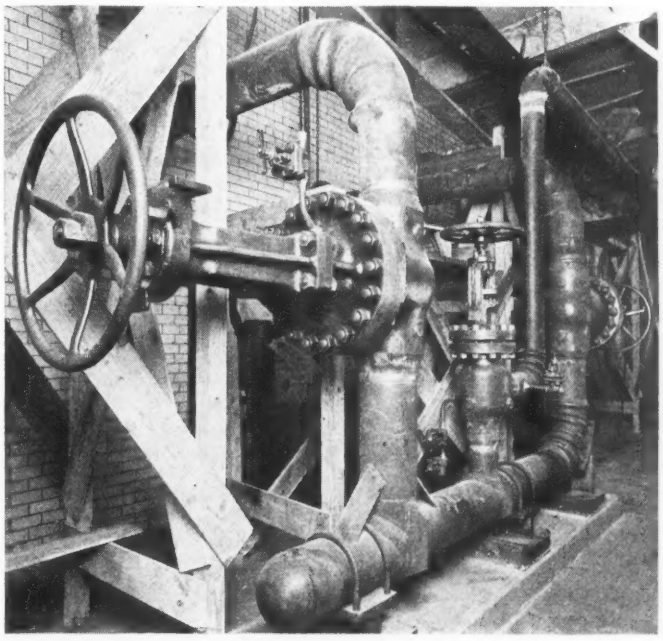
Pipe size must, of course, be based on the volume of the fluid to be carried. The size must be such as will result in reasonable velocities and pressure drops of the fluid flowing. The following table gives velocities which experience indicates are reasonable for various services.

| | Velocity, Ft. per min. |
|---|---|
| **Steam** | |
| Boiler leads | 6,000 to 12,000 |
| Headers | 6,000 to 8,000 |
| Branch lines | 6,000 to 15,000 |
| Exhaust lines | 6,000 to 15,000 |
| Saturated steam for heating | 4,000 to 6,000 |
| **Water** | |
| Boiler feed | 480 to 600 |
| General Service | 300 to 600 |
| City | 120 to 300 |

It is possible in many cases to determine the pipe size by economic analysis. For example, consider the case of piping to supply steam to a turbine. The smaller the pipe installed the less its first cost and yearly carrying charge. But the smaller the pipe the greater the pressure drop, which increases the turbine steam rate and hence the cost of fuel per kw.-hr. With given cost of fuel and load factor, a pipe size can be found which will result in the lowest total fixed charges on cost of pipe and insulation, and cost of fuel for supplying steam to the turbine. In some instances limited allowable pressure drop will determine pipe size.

With these preliminaries completed, the designer is ready to lay out the system to meet the physical requirements of the plant. Drawings and specifications that he makes should be complete and leave nothing to the imagination. There are usually a great variety of ways the piping can be run, but the designer must remember that his work will be judged by the reliability, appearance and ease of operation of the installation. Ease of operation is often neglected and, as a result, the operator finds it necessary to set up a stepladder or crawl over a maze of piping to operate certain valves. All

**More and more piping is being welded, utilizing tube ends and welding-neck valves and fittings. This is some of the H. T. piping for Connors Creek.**



valves should be as accessible as possible; those operated regularly should be within easy reach, or remote control provided. Valves used regularly require repair, and space for maintenance should be allowed when location is chosen. Arrangements of bypasses should be such that the purpose of each valve is evident at a glance.

Much can be done in the early design of a power plant to help in securing neat and well-appearing piping by providing pipe galleries and by considering piping when locating turbines, pumps, heaters, etc. Assembly drawings are almost a necessity to good appearance, and in large installations a model of the plant including the main piping repays its cost by eliminating many mistakes (See page 59). In general, elbows look better than bends, and pipe run out at 45 deg. should be avoided. Piping should run parallel or perpendicular to the axis of the plant and should be kept in a single plane as far as practicable. Where clearances are close, the designer should remember to provide room for flanges and insulation. Of course, welded piping takes up less space.

### Provide for Expansion

All power piping is subject to temperature changes. While this is particularly true of steam piping it is true also of service-water piping where temperature changes of 60 deg. may be encountered between winter and summer conditions. Temperature changes cause changes in the length of pipe. Unless provision is made to accommodate them, severe and dangerous stresses and thrusts may damage the pipe or connected equipment.

It is easy to figure the change in length of a run of pipe with temperature change, which should be taken as the maximum possible. When the average coefficient of expansion of the pipe material is known, change in length may be found from the formula $D = 12\ CL\ (t_2 - t_1)$* where $D$ is increase in length in inches, $L$ length of pipe line in feet at temperature $t_1$, $t_1$ and $t_2$ initial and final temperatures and $C$ average coefficient of expansion.

| Metal | Average Coefficient | Temperature Range |
|---|---|---|
| Cast Iron | 0.00000653 | 0 — 300 |
| Steel | 0.00000756 | 0 — 500 |
| Wrought Iron | 0.00000716 | 0 — 300 |
| Brass | 0.0000101 | 0 — 250 |

There are two ways in general use for taking care of expansion: 1—expansion joints; 2—flexibility of the piping system obtained either by expansion loops and bends or change in direction. When space is limited creased and corrugated bends may provide a solution. The analysis necessary to determine the expansion a piping system may safely stand due to its own inherent flexibility are too complex to explain in these articles, and should be entrusted only to a specialist in this field. Methods of analysis have been quite completely treated in the "Piping Hand Book"[1] and a practical graphical method is given in "A Manual For The Design of Piping For Flexibility by The Use of Graphs."[2] Designed pipe flexibility is used to absorb expansion in all high-pressure piping systems.

Combinations of welding elbows and straight lengths of pipe are also being advocated for expansion.

For lower pressures (up to 250 to 350 lb.) expansion joints are in general use. These are of two types: slip type and packless joints of corrugated metal or rubber. When expansion joints are used, pipelines should be well supported and guided so that no binding in the joint will occur as the pipe expands and contracts. Slip-type joints usually permit more movement than the packless joint, but packless joints can be installed in less space.

Before expansion stresses can be calculated, it is necessary to decide upon points of fixed and sliding anchorage and the means of pipe support. Fixed anchorages are usually made at important junction points and are designed to fix the pipe vertically, transversely and longitudinally.

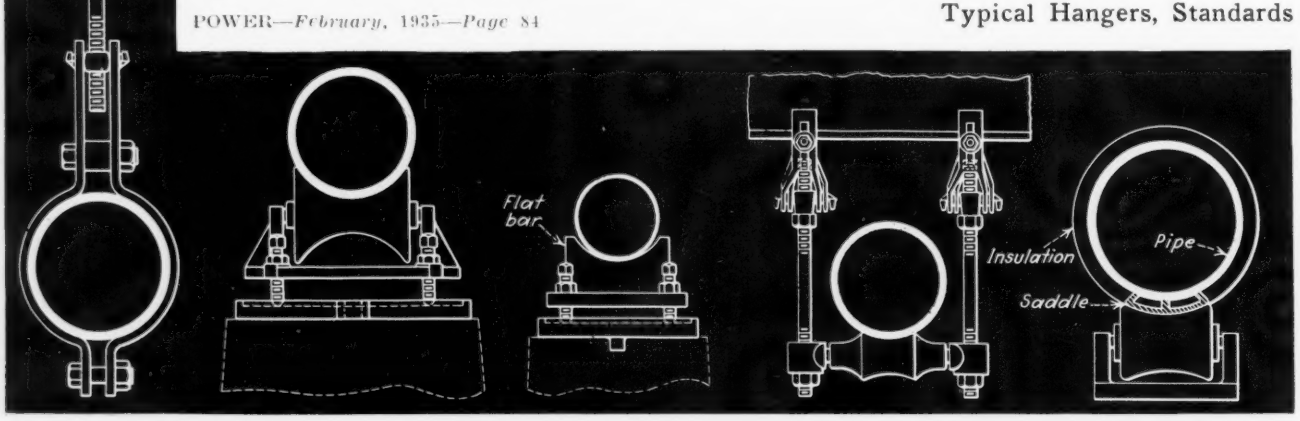
In general, it has been more convenient to support power-plant piping on hangars or on brackets from building columns. Piping run in tunnels, however, is usually supported from below. In either case the supports must be arranged to permit movement of the pipe. Hangers should always be arranged to allow vertical adjustment. Each support should be strong enough to hold its share of the pipe and insulation when filled with water. With solid hangers a safety factor of 10 should be used, because pipe expansion sometimes lifts it clear of one or more hangers, thus concentrating the weight. With spring hangers, the safety factor can be cut to 5, as these types compensate for pipe movement. Certain special patent hangers are designed to permit the line to move up and down while they exert a constant supporting lift. With ordinary spring hangers the supporting lift of the hanger decreases as the pipe moves vertically and the springs close.

Supports should be spaced and adjusted so that drainage is assured and pipe deflections will not form pockets. The chart on page 92 will help to determine the proper distance between supports.

*A more complicated but more precise equation for calculating expansion is the Holburn & Day formula given in "Piping Hand Book."



**Typical Hangers, Standards**



Sway bracing should be used to prevent pipe vibration and to keep the lines in place. These are particularly necessary on boiler feed lines where violent vibrations often result from surges caused by sticking control valves, air bound pumps and other causes of water hammer.

### Pipe-Line Drainage

All piping, whether for water, air, saturated or superheated steam, should be arranged for drainage. In water piping drains should be provided for each section of the system, so that the line may be emptied of water when repairs are necessary. In the case of steam lines, however, drains and trap connections must be provided to keep the line free from condensate whenever it is in operation. Drainage piping should not be less than $\frac{3}{4}$ in. Steam piping should be arranged so that pockets are avoided as much as possible. When they are necessary they should be well drained. Lines should be installed with a uniform grade of 1 in. in 20 ft. so they will drain to a definite point. Better drainage is obtained if the lines are sloped in the direction of steam flow. Particular care should be taken in locating valves to see that condensate will not accumulate on top of the valve when closed; if such location can not be avoided ample drain facilities must be provided. Neglect of this point will cause trouble, particularly in the case of valves in boiler leads and turbine or engine stop valves.

Although little condensate collects when superheated steam is flowing, such lines should, nevertheless, be provided with drains, as considerable condensate will collect when superheated steam lines are shut down. This must be removed before the line can be put in service again. Open blows are essential in warming up steam lines to insure expulsion of air and condensate.

Whenever a steam line approaches a turbine or engine from above it is good practice to provide a drip pocket with drain connection at the bottom. In fact the bottoms of all vertical risers should be trapped. Successful operation of steam and oil separators depends largely upon the reliability of the drain facilities provided. Drip and trap piping operates under more severe service conditions than the main piping and for this reason is often made of heavier standard than the main piping.

An essential factor in the economical installation and successful operation of a piping system is the valves selected, and any discussion of piping without considering valves would be incomplete. However, in the limited space of this article only general suggestions pertaining to valve selection can be given. Globe valves are used in those places where throttling is a service requirement. Globe valves are seldom used in water lines because of pressure drop through them. Gate valves are used where pressure drop is a consideration and in locations where the valve will be either wide open or completely closed. Control valves (globe) should be preceded by gate valves located usually near the header so that the line can be shut tightly for repair to the control valve. When a valve is subject to severe cutting a guard valve, usually a gate, should be provided for tightness such as is done for boiler blow-off connections.

Check valves should be installed at the discharge of all pumps that deliver to a common header to automatically prevent back flow when the pump is shut down. They should not be counted upon to be tight, and a gate should be used with them. Check valves should be used at the feedwater inlet to the boiler, with gate valves on either side, and in drip lines that discharge to a common header or receiver.

Small valves, as used for instrument piping, drip connections, etc. are usuaally globe valves. It is good practice to install a valve close to the point where instrument piping connects to the main piping, and an open blow connection, with valves on both sides of it, at the instrument. This arrangement permits blowing out the line without danger of injury to the instrument. It also provides a place for checking accuracy of the instrument.

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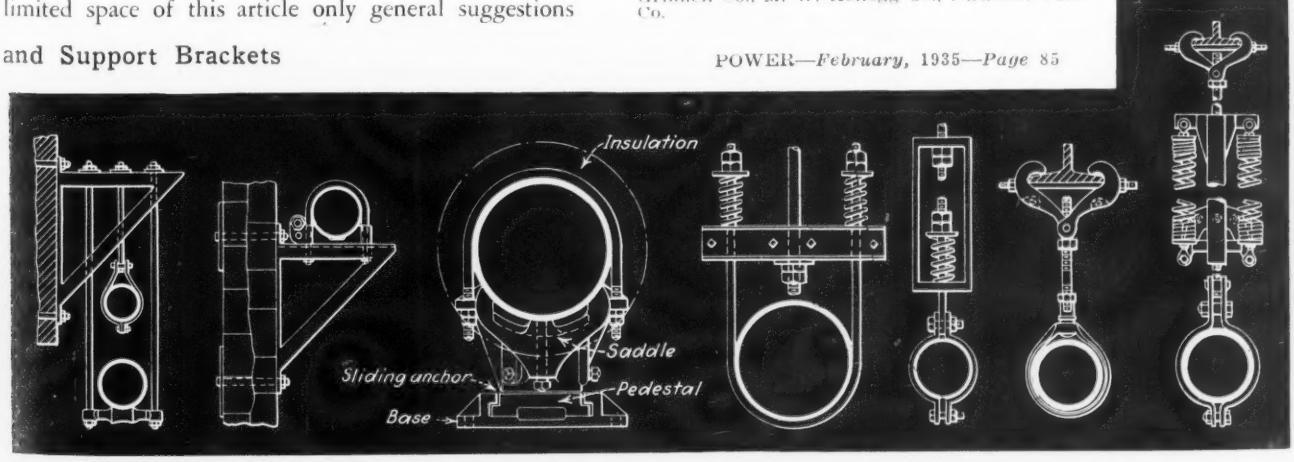
and Support Brackets





# PIPING —INSTALLATION

ONCE a piping system is laid out, the tyro considers his troubles over. But anyone who has ever installed piping knows better. No matter how detailed was design, there will be cases where two pipes try to occupy the same space at the same time, where joints fail to fit together, where piping has been entirely forgotten. In fact, in many industrial power installations, designers simply indicate where auxiliary piping is connected and make no effort whatsoever to show where the lines themselves are to be placed. Thus the pipe installation gang has the two-fold task of correcting mistakes that occur in design and layout, and of doing empirical design on the job.

First essential of sound installation is proper supervision. Fabricating companies have achieved this result, plus coordination between designing and erecting groups, by placing one engineer in charge of a job, his being the responsibility from preliminary layout to final testing. This man is thus at all times thoroughly familiar with the job and the reasons for doing certain things and for not doing certain others. With this background he can anticipate difficulties of the erecting crew and make the necessary changes before the work has advanced so far that correction is costly.

First essentials of good installation are sound equipment and safe rigging. Good lumber or staging, annealed chains, fairly new rope, unspread wrenches, clean sharp threading dies, goggles (where chipping is required), tight-headed hammers and sledges, socket wrenches if possible, varied cutting-torches and a wide variety of tips for welding torches where welding is to be done—these are all worthwhile investments for trouble-free installation. In fact, a list of necessary tools for proper pipe-fitting may not be amiss, even in this restricted space. They are:

Brick-cutting, cape, diamond-point, round-nose, cold and wood chisels; ¼x12-in. and ¾x24-in. star drills; set of twist drills and auger bits to 1 in., expansion bit with feeler bit and brace (ratchet type); screwdriver; level; plumb-bob; snips; set of hex wrenches for radiator rods; stock and dies ⅜-1 in., 1-2 in. and for bolts; pipe taps; cutters for ⅜-1 in. and 1-2 in. pipe; reamer; vise; a good workbench; oiler; flat and half-round files; hacksaw and blades; handsaw; compass saw; pliers; radiator spud wrench; radiator bar set; 10 in., two 14-in., two 18-in., two 24-in. pipe wrenches; 10-, 14-, and 18-in. monkey wrenches; claw-, 1¼-lb. ball-peen, 2½-lb. hammers; sledge; 30-in. wrecking bar; steel tape; 6-ft. rule; combination ⅜-in. tap and drill, blowtorch.

In addition to this kit, the crew will require specialized tools depending upon the type of piping being installed, such as chain wrenches for large-diameter screwed-joint pipe, open-end wrenches, etc.

Threading is a simple task for the pipeman who keeps his dies clean, sharp and new and uses good stocks or threading machines in proper condition, with proper lubricants. Complete information on threading can be obtained from handbooks, piping manufacturers or equipment makers, showing approved methods of handling given types of equipment, how long a thread is to be run and other pertinent data. Threads should be clean—on a high-pressure line a scratch across the threads may cause failure. Joints nowadays are most often made up with graphite and oil, although Smooth-on or litharge and red lead are also used.

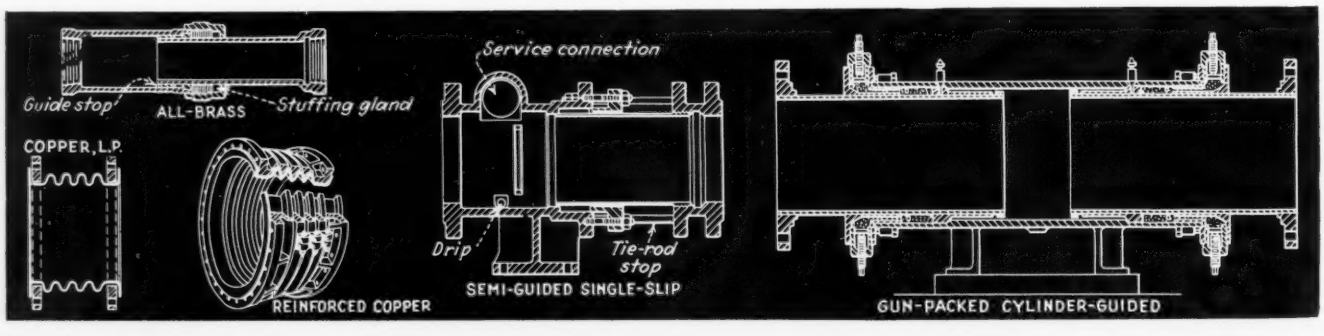
Bending is a specialized field, the best advice for any installer being the suggestion that he find a man with a good background of experience, then hang onto him, for even good pipe-bending equipment is of little value in the hands of men unskilled in its use. Larger sizes of pipe are usually supplied bent to shape nowadays, the only task for the erector being an occasional slight rebending to suit slightly altered layouts. It is essential that mating edges meet exactly to avoid joint failures under temperature and pressure. During installation, a suitable pipe-bending table should be set up, formed either of structural shapes or of cast-iron set in concrete. Holes or clamps are provided so that suitable stops can be set up, around which the pipe is to be bent. Small pipe can then be bent around the stops by hand, larger sizes may require block and tackle, hoist, or crane. A simple heating furnace should be provided; one can be built easily of refractory brick sidewalls, with hinged top and drop-end curtains of asbestos.

Where many small sections of pipe are to be bent, a small bending machine may be a good investment. One company had an air cylinder and piston with a semi-circular-grooved roller at its end. This passed in and out between two similar rollers on the ends of a U-frame of plate. Thus pipe sections could be bent at any angle or combination of angles up to a full U bend, and the semi-circular grooves prevented kinking. Smaller sizes may be bent cold, larger sections, or those subjected to pressure or temperature should be heated.

In bending, flanging or other working, the erector must remember the characteristics of various types of pipe—the tendency, for example, of butt-welded and lap-welded pipe to split open.

Flanged joints require careful alignment, not only of the pipe sections in contact, but of the bolt-holes in the flange faces, so that no twisting or cocking strains

**Typical Expansion Joints**



are introduced. Flange bolts should be taken up in definite order, a little at a time, rather than attempting to pull one or two up tight and then spin the others in by hand. Threads on flange bolts should be reasonably tight, but not so tight that excessive pressure is required to overcome thread resistance. If such bolts are used, the effort that is supposedly going toward pulling the flange up tight may be wasted in overcoming thread friction and the joint itself may be loose. Flange bolts should never be pulled up with a monkey wrench or sprung open-end wrench, both because of the danger to the erector and because of the battering up of the nut faces. Either substantial open-end wrenches or socket wrenches should be used.

In hanging pipe, it is essential that the section fit naturally into the hangers, and considerable time should be put in adjusting them to make certain that the section is hanging in proper alignment before any bolting up is done. To do anything else simply invites trouble. Spring-type hangers should be carefully adjusted so that they carry nearly equal loads, otherwise when a stress comes on, one spring may be overloaded and fail. Pipe clamps themselves, rather than being battered onto the pipe into a rough circle, should be forged in a semi-circular die. Proper pitch of a run of piping is also an important job of the erector; he must be certain that the pipeline carries enough pitch so that it will drain properly (see page 93).

There are several small points that should be apparent to any good erector, yet a surprising number of times it is just such small mistakes that cause later trouble. One is to clean out every section of piping before it is put up—blowing or brushing out (as far as possible) any loose scale, turnings, bits of oily waste or dirt that may have gotten inside. Another is to ream every pipe end. Another is to be certain that valves face correctly when they are installed; more than one job has caused trouble because a valve was put in backwards. Another is to build a small scale model where complicated piping is to go in.

# —INSULATION

THIS article can only touch the high spots, for lack of space. Detailed information and dependable application specifications are given in the catalogs of established manufacturers.

Pipe covering serves first as a barrier or dam to the flow of *heat*. At the same time it must not deteriorate at the temperature of the pipe. Other requirements for a good pipe covering for hot or cold lines are: practically air-tight application (absolutely air-tight in case of cold lines); sustained strength; ability to resist occasional wetting; ease of application; ease of removal and reapplication without damage; good appearance.

For the insulation of hot water and steam lines in industry, there is little place for the cheap "air-cell" types of asbestos insulation used on domestic jobs. Suitable insulations for these jobs include "85% magnesia," felted asbestos, various types of mineral wool. Perhaps most widely used in this service is molded 85% magnesia—a non-proprietary product of several manufacturers.

Molded insulation for small pipes comes in 3-ft. sections cut in half and covered with light-weight pasted canvas. For a first-class power job the halves are bound in place with loops of 16-gage *annealed* iron wire, covered with rosin-sized sheathing paper, then with 8-oz. canvas sewed in place with linen thread. The canvas is then glue-sized and painted with two or more coats of oil paint.

The "standard" thickness covering referred to in Table I is primarily an "85% magnesia" standard. It is about 1 in. for pipes less than 4 in.; $1\frac{1}{8}$ in. for 4-in. pipe, $1\frac{1}{4}$ in. for 8-in., $1\frac{1}{2}$ in. for 12-in. and up. "Double standard" consists of two standard-thick layers. These are applied one over the other, with all joints staggered. The inner layer, without canvas, is separately wired.

Very large pipes (as well as drums of heaters, boilers, etc., are lagged with molded blocks, machined to fit curvature, wired in place, covered either with hard-finish cement or with sheathing paper and sewed 8-oz. canvas. Large fittings, flanges, etc., are often covered with casings built up of insulating blocks and cement, wire reinforced. They may be made removable. Small fittings are insulated either with cement or with premolded covers. Pipe bends are insulated with short pieces of block or sectional covering, wired on, filled with insulating cement and covered with hard-finish.

Ordinary asbestos and magnesia insulations begin to disintegrate at 550 or 600 deg. For higher steam temperatures use an inner layer of high-temperature molded insulation (See Table) or use a straight mineral-wool insulation adapted to high temperature.

The good insulating qualities cheaply obtainable with felted hair or wool can be utilized in the case of pipes carrying somewhat warm or somewhat cool water, the former not hot enough to destroy the organic matter, the latter where the principal object is to prevent sweating in humid weather.

In the case of refrigerating piping, good insulating value and right thickness are no more important than air-tight application. Entering air will deposit frost and eventually ruin the insulation. Application requires skilled use of sealing-compound layers between layers of insulation. This is distinctly a branch for specialists; they should always be called in on any important job.

## Approximately Recommended Thicknesses for Insulation

| Pipe Size | Temperature of Pipe Surface—deg. F. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | −60 to −20 | −20 to −10 | −10 to +5 | +5 to +25 | 25 to 50 | 50 to 70 | 70 to 300 | 300 to 450 | 450 to 600 | 600 to 700 | | 700 to 800 | | 800 to 900 | |
| | Standard Hair Felt | | | | | | 85% Magnesia | | | H. T. | Mag. | H. T. | Mag. | H. T. | Mag. |
| Under 2 in. | 5 | 4 | 3 | 3 | 2 | 1 | St'd | $1\frac{1}{2}$ | 2 | 2 | .. | 2 | .. | 2 | .. |
| 2 to $3\frac{1}{2}$ in. | 5 | 4 | 4 | 3 | 2 | 1 | St'd | $1\frac{1}{2}$ | 2 | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 2 | 2 | 2 |
| 4 to 6 in. | 6 | 5 | 4 | 3 | 2 | 1 | St'd | 2 | D. S. | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$ | 2 | 2 | 2 |
| 7 in. and over | 6 | 5 | 4 | 3 | 2 | 1 | St'd | 2 | D. S. | $1\frac{1}{2}$ | 2 | 2 | 2 | $2\frac{1}{2}$ | 2 |

St'd = Standard Thickness. D. S. = Double Standard Thickness.
H.T. = Inner Layer of special molded high-temperature insulation.

# PIPING—MAINTENANCE

CORROSION is the maintenance man's worst enemy. Anything he can do to prevent it—tighter joints, system redesign, changed materials or operation—redounds to his own advantage. Dissolved oxygen comes first as a cause of power piping corrosion, particularly in hot feedwater lines. The remedy is to keep oxygen out of the system or take it out with deaerating heaters. Feed heaters should be amply vented and vacuum-type heating systems kept tight against air infiltration. Men should be cautioned against hunting for H. T. steam leaks by passing hands over joints. H. T. steam is invisible and burns very seriously almost instantaneously.

Most important is frequent routine inspection, which, with orderly scheduled maintenance, will avoid emergency repairs. Units requiring regular repacking, inspection or cleaning should be provided with bypasses or be in duplicate as should vital valves and auxiliaries. Steam, feed and service water lines which must be kept in service at all costs should likewise be in duplicate. If traps on the dead side of a duplicate system fail to operate (if the system is kept alive or valves leak) pipes will fill with water and cause leaky joints. Traps should be installed with shut-off valves or bypasses.

No maintenance man can work successfully without proper tools and supplies. This means that he must have lengths of pipe of the sizes, types and materials he must replace, plus an ample assortment of fittings, valves and gaskets (see page 82). Packings for joints and valve stems, reseating tools, a supply of good lumber for scaffolding and supports (instead of the usual reused and dangerous odd bits) annealed chain and several sizes of rope should supplement the usual pipefitter's tools, as well as equipment for detecting leaks in refrigerant lines and determining stresses in flange bolts on high-temperature lines.

Even the heavy forged high-temperature steam lines at Deepwater Station (Tex.) are arranged for periodic dis-assembly. The fabricator drilled and tapped each nut for an Alemite fitting through which rust-preventing lubricant could be shot before any attempt at taking down. Differential expansion in this class of service is a terrific maintenance problem, requiring special flange designs or the increasingly popular shift to welding.

Important in maintenance is the difficulty of removing a pipe section. Tongue-and-groove or male-and-female flange joints (except large V. S. where flanges can be slipped back) require wedging apart of abutting flanges. This should be done at the next flange or support to avoid damaging machined faces. One company does not insulate flanges, claiming that thus gasket leaks can be detected more readily. Large diameter thin-walled pipe should be handled carefully, and if threaded be set up by all-around wrenches instead of the usual 2-jawed types to avoid crushing. Socket wrenches are preferable to open-end or adjustable wrenches for removing or tightening flange bolts.

Proper system design, correct hanger spacing and enough expansion joints will avoid vibration. Expansion joints are a vital element in maintenance. Sometimes there is trouble with an expansion bend which does not fit accurately, meaning a change in the bend. Sleeve-type expansion joints require regular lubrication and repacking. Pipe hangers, spring hangers and anchors must be inspected regularly to avoid shifting and bad stresses or failure, and one man should be trained for their particular repair. New pipe, before installation, must be cleared of dirt and dirt pockets must be cleaned out of old pipe periodically, particularly in heating systems.

Some standard system of pipe identification is important. Pipe lines normally should be painted to match the color scheme of the plant or building, even if insulated. Metallic paints reduce heat emission on hot bare pipe. Wood, lead, tin, zinc, bitumastic and other tarry compounds, paints and more recently, rubber, have been used as protective coatings against corrosion and erosion (for example in rubber-lined ash-sluicing systems) but engineering opinion is about evenly divided on their value. The best bet is to find out what's happened in nearby plants.

Basic in maintenance work is proper makeup of joints. Procedure is given on page 86.

# —JOINTS

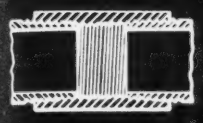
PIPE designers have supplied so many types of joints, each with its particular virtues, that the power engineer is in a quandary. On the facing page are 25 common joints for power service and process piping, each with its virtues, each with its faults.

While the primary purpose of any pipe joint is to withstand internal pressure, it must also withstand possible stresses due to bending, expansion and contraction, line load, over-rigidity of the system, unequal initial tension in flange bolts, poor machining (far too often, facing the backs of Van Stone laps is neglected, giving poor flange alignment), unparallel flange faces —even poor basic design. Any of these are likely to impose stresses far above those created by internal pressure. In screwed joints, factors of safety must provide liberally for corrosion.

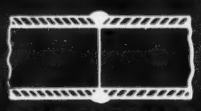
Major piping systems, particularly those for high temperatures or pressures, should be designed by specialists.

On the bottom of the facing page are a few typical fittings for each important assembling method. In this connection, it should be mentioned that a number of special patented fittings are available for use with non-ferrous materials or stainless steels for ordinary service.

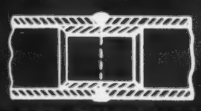
# TYPICAL JOINTS



**SCREWED COUPLING**
Smaller sizes, low T. and P. T. changes cause high maintenance. Threading cuts strength and thickness 40%.

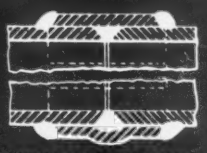


**V-TYPE BUTT WELD**
Increasingly common. Requires skilled welders, careful allowance for T. expansion, support and anchoring.

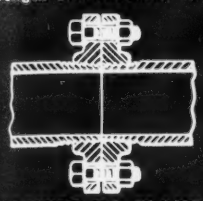


**V-TYPE, CHILL SLEEVE**
Sleeve inside joint avoids "icicles" from welding but reduces internal diameter. Also for high T. and P.

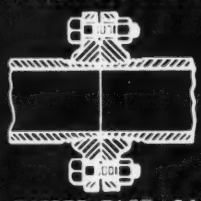
**BELL-AND-SPIGOT**
Avoids icicles without reducing internal diameter. Small sizes. Requires pipe belling. Harder to erect.



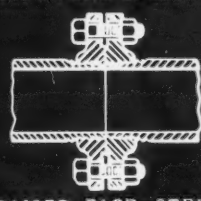
**EXTERNAL SLEEVE**
Upper type gives smoother surface but weld must be ground off. Lower retains bead. Both costly, doubtful.



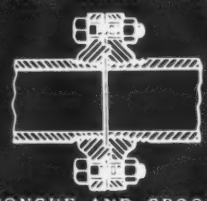
**SCREWED C.I. FLANGES**
Inexpensive, good for low P. and T. under 12-in. dia. Lacks strength. Low gasket pressure; easy blowout.



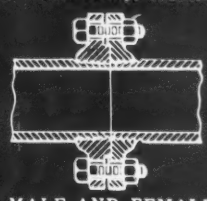
**RAISED FACE—C.I.**
Higher unit gasket pressure but must be bolted up carefully to avoid cracking. Never mate with steel flange.



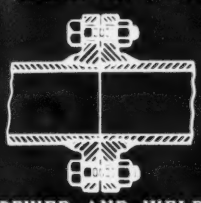
**RAISED FACE—STEEL**
Better strength, same coef. of expansion as pipe. Flanges refaced after on pipe to avoid distortion.



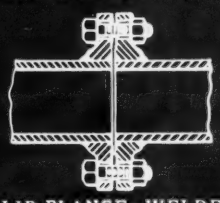
**TONGUE AND GROOVE**
High gasket pressure and locks gasket. High T. changes crush gasket or mushroom tongue. Hard to erect.



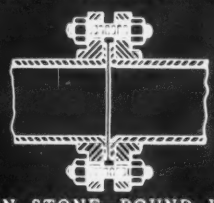
**MALE AND FEMALE**
More rigidity, avoids excessive gasket pressure, but difficult to lay out, erect, maintain. Gasket nearer bolts.



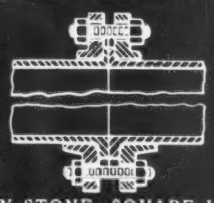
**SCREWED AND WELDED**
Steel flanges. Avoids thread leakage, but heat of welding causes trouble. Flanges should be refaced after welding.



**SLIP FLANGE—WELDED**
Requires two welds, refacing flanges. No threading. Hard to align bolt holes. Welding neck and butt-welding flange better.



**VAN STONE—ROUND LAP**
Moderate T. and P. Can be formed in place, but warps flange. Non-uniform gasket pressure, thin bend.

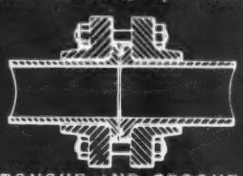


**VAN STONE—SQUARE LAP**
Med. & high T. & P. No water pocket, heavy fillet, rigid, strong. May be seal-welded, usually faced. Also 200% lap as below.

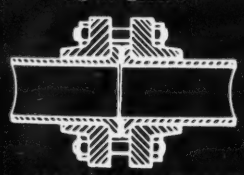
**SARLUN JOINT**
No gasket, but machined faces. Lips seal-welded. Hard to take apart; then requires remachining or gasket.

**TEXAS JOINT**
Up to 6 in. Wedges flanges. Joint may leak under rapid T. changes. Water collects in horizontal lines, may leak.

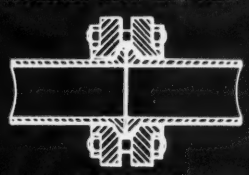
**MIDWEST JOINT**
Ground spherical contact surfaces. Smaller lines. No gasket, but high-tensile bolts and care in mating.



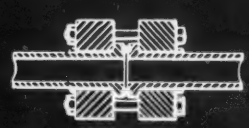
**TONGUE AND GROOVE**
Like 200% lap Van Stone. More mating surfaces. Harder to erect, design, and disassemble; groove weakens lap.



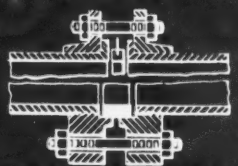
**MALE AND FEMALE FACING**
Used with double-weight lap. Hard to design, erect and take apart. Extra machining.



**"GLOBACK"**
Modified double-thick lap Van Stone, giving wedge action of flanges. Forces outer surfaces of lap together.



**TOROIDAL RING**
Inserted ring giving more sealing faces. More machining and greater care in erection. Hard to take down; grooves weaken.



**COPPER-PLATED GASKET**
Another modification with copper-plated gasket. Used either between flat mating faces or in double-recessed type, as below.

## Typical Fittings

WELDED

90° Elbow  Return Bend

Welding neck

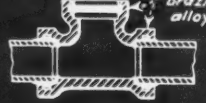
SCREWED

90° Elbow  Lateral

FORGED

Three unions

COPPER




Coupling

CAST STEEL, BRASS, ETC.

Tee  Saddle Outlet  Butt-welding Flange

Cross  True Y

90° Elbow  Tee

Flared coupling

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# PIPING —FOR OVER 850 DEG.

*By Sabin Crocker and Arthur McCutchan*
*Engineering Division, Detroit Edison Company*

RECENT increases in steam temperatures of 100 to 150 deg. over previous top temperatures, bringing present total temperatures to 850 or 900 deg., have accentuated the importance of certain items of piping design. The problem is largely one of metallurgy and economics involving the interrelation of cost with long-time load carrying ability of available materials at elevated temperatures. Although development of low-alloy steels having sufficient creep strength and stability at temperatures up to 1,000 deg. will eventually make possible economical use of higher temperatures, present balance between possible fuel saving through use of higher temperatures and attendant increase in construction costs does not appear to warrant steam temperatures above 850 to 900 deg. for some time to come.

The following items are presented somewhat in the nature of a "check list" covering those features of piping design which require special consideration when selecting piping materials and dimensional standards for high-temperature service.

## Selection of Pipe

Diameter of pipe, material and wall-thickness are interdependent. Since in pipe practice outside diameters remain constant, an increase in wall-thickness causes a corresponding decrease in inside diameter and consequently in carrying capacity of a given pipe size. Wall-thickness in turn depends upon the material selected. Choice of pipe material and the assumptions of working stresses as determined by the designer may be given a preliminary check through comparison with the points developed below.

Ordinary carbon steel at 850 deg. retains about $\frac{2}{3}$ of the ability to sustain load it possessed at 750 deg., while at 950 deg. its long-time strength is only about $\frac{1}{3}$ of that at 750 deg. Reduction in strength of carbon steel with increase in operating temperature is shown graphically in Fig. 2. It should be noted that long-time strength falls off more rapidly with increase in temperature than short-time tensile strength. This difference, as shown by the curves of Fig. 2, emphasizes the point that in designing for continuous loads at temperatures of 850 deg. creep data rather than results of short-time tests at the operating temperature should be used.

Up to 850 or 900 deg., either of two courses may be followed: (1) increase wall-thickness to compensate for reduction in strength; or (2) select a material whose long-time strength does not fall off so rapidly with increase in temperature. Above 900 to 950 deg., only the latter course should be considered.

A special analysis silicon-killed medium-carbon steel was selected for a recent 850 deg. installation on the basis of excellent short-time physical properties at room temperature and creep tests which indicated that an allowable bursting stress of 7,000 lb. per sq.in. could be assigned to this material. This stress was approximately $\frac{2}{3}$ of the stress which tests indicated would produce creep of 1 per cent in 100,000 hr.

Wall-thickness determined by different piping designers using the same value of allowable bursting stress may be quite different depending upon the bursting stress formula employed, whether the same addition for corrosion allowance is made, and whether adherence to commercial pipe wall thickness is required.

At least four formulas for calculating bursting stress in pipes are in common use. Of these formulas, Barlow's and Clavarino's are perhaps best known. Although Clavarino's formula is considered a more rational attempt to take effects of internal pressure into account, recent full-size bursting tests indicate that Barlow's formula gives a better prediction of the bursting pressure. It should be recognized that the theoretical wall thickness will be greater if Barlow's formula is used. For example, the theoretical wall-thickness of a 10-in. pipe designed for 650 lb. per sq.in. and 850 deg. F. will be 16 per cent greater if Barlow's formula is used in place of Clavarino's. The relation of bursting stress and longitudinal stress as they act on an element of the pipe wall is indicated in Fig. 1.

In determining pipe wall thicknesses it is customary to add 0.065 in. to the theoretical thickness to obtain the minimum wall-thickness on inspection. This addition is referred to as an allowance for corrosion. In case of pipe for 850 deg. steam, the corrosion allowance merely represents an additional margin of safety. But, as steam temperatures are increased above 950 deg., the reaction of carbon steel with hot steam forms a black iron oxide, $Fe_3O_4$, with a consequent possible reduction in wall thickness.

To provide for an underthickness mill-tolerance of $12\frac{1}{2}$ per cent, nominal thickness is customarily found by dividing minimum thickness by 0.875 and then selecting the next heavier commercial thickness.

As a consequence of these several additions, a considerable margin existed in the pipe selected for 650-lb. per sq.in., 850-deg. service over and above that indicated in the statement that a bursting stress of 7,000 lb. per sq.in. was used in determining wall thickness.

## Selection of Pipe-Joints

Although serviceable bolted joints can be designed for operating temperatures of 850 deg. and higher, either extremely heavy construction or expensive materials are required if complete freedom from leaky joints is to be obtained. Fusion welding of all line joints is now practical on piping for high-temperature service, providing all welding is done by competent operators working under careful supervision. For larger sizes, butt-welded joints with "chill" rings to prevent weld spatter falling inside the pipe are considered desirable. In smaller pipe sizes, sleeve and socket-welded joints make an effective and economical type of joint well suited for high-pressure and high-temperature service.

Where ready disassembly of a joint is required, as at connections to turbines or at valve-bonnet joints, bolted joints must still be used. The flange standard selected should be heavy enough to insure adequate compression on the contact surfaces at the end of the expected period of service. Where sufficiently accurate creep data are available, a design in which flange and bolt stresses required to give this joint loading are less than $\frac{2}{3}$ of the values reported as causing creep of 1 per cent in 100,000 hr. gives promise of being a satisfactory joint.

Bolting material with extremely high short-time physical properties at room temperature combined with good creep resistance appears to give the most satisfactory results. High short-time tensile strength enables the joint to be set up initially with a relatively high bolt loading and yet have a margin to care for the additional stress caused by temperature differences between the inside of the joint and the bolts when bringing the line up to temperature. High creep resistance is essential to maintain the necessary axial load on the joint over a period of years.

When a piping layout for 850-deg. steam is checked against a similar layout for 750-deg. service, it may be helpful to remember that the forces and bending moments will be increased about 10 per cent by the increase in temperature. A line heated to 850 deg. will elongate approximately 17 per cent more than at 750 deg., but the attendant drop in value of the modulus of elasticity is such that the net increase in reactions is only approximately 10 per cent.

## Size and Thickness

Since magnitude of reactions is directly proportional to moment of inertia of the pipe, use of pipe larger in diameter or of greater wall thickness than required by conditions of flow and internal pressure is undesirable. The magnitude of permissible thrust on the turbine flange limits reactions in the turbine leads, but boiler leads and interconnecting piping may be designed to advantage for reasonably high bending moments at points remote from joints. Since many instances of leaks at bolted joints can be attributed to lack of flexibility in the pipe line, it is desirable to keep bending moments at bolted joints relatively low.

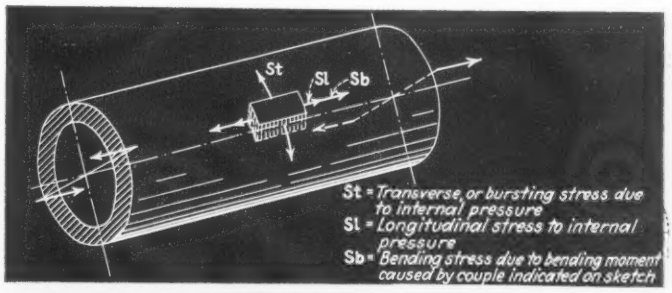
To secure adequate flexibility and at the same time have an economical pipe layout, a distinction can be made to advantage between stress which may exist in curved portions of the pipe line due to flattening effects and the like and stresses accompanied by bending moments which tend to pry bolted joints apart. As a check on values of bending stress considered reasonable for 850-deg. service, the following assignments of total allowable combined longitudinal pressure plus longitudinal bending stress may be of interest: at points removed from joints, 15,000 lb. per sq.in.; at both bolted and welded joints, 10,000 lb. per sq.in.

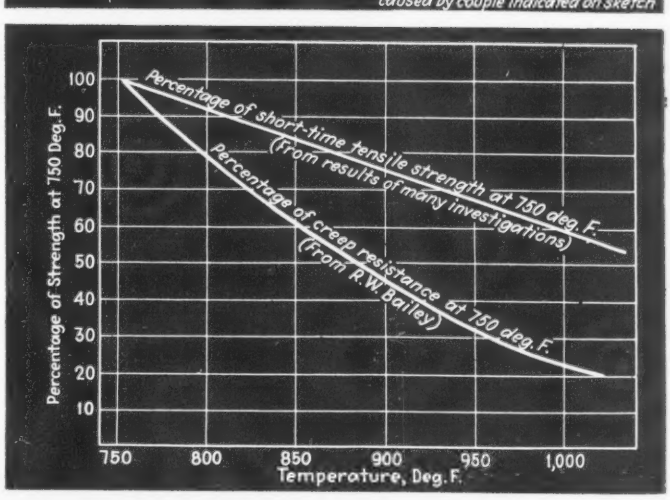
Selection of an allowable bursting stress of 7,000 lb. per sq.in. and an allowable bending stress of approximately 12,000 lb. per sq.in. is based on the reasoning that a distinction can properly be made between stresses caused by internal pressure, which must be supported continuously, and those arising from constraint of thermal elongation. Accommodation of the line to a shape of lower stress will tend to reduce the latter to a value which the material can support, while any pronounced flow caused by a bursting stress would tend to increase the value of the stress. A better appreciation of this statement is possible through a little study of the stress relation shown in Fig. 1.

## Effect of Cooling

When a line is cooled to room temperature after an extended period of service at operating temperature, reverse stresses may be expected equal to the difference between the bending stresses existing when the line is first brought up to temperature and those remaining after the period of service. In this respect, creep at operating temperature under bending stress gives the same effect in the cold condition as cutting the pipe short.

**Fig. 1 (Top)—Relation of bending stress and pressure stress in pipe. Fig. 2 (Bottom)—Decrease in strength of carbon steel above 750 deg.**


St
Sl
Sb
St = Transverse, or bursting stress due to internal pressure
Sl = Longitudinal stress to internal pressure
Sb = Bending stress due to bending moment caused by couple indicated on sketch



# Expansion Bends, Pipe Gradient, Support Spacing

## EXPANSION BENDS

Table giving expansion cared for

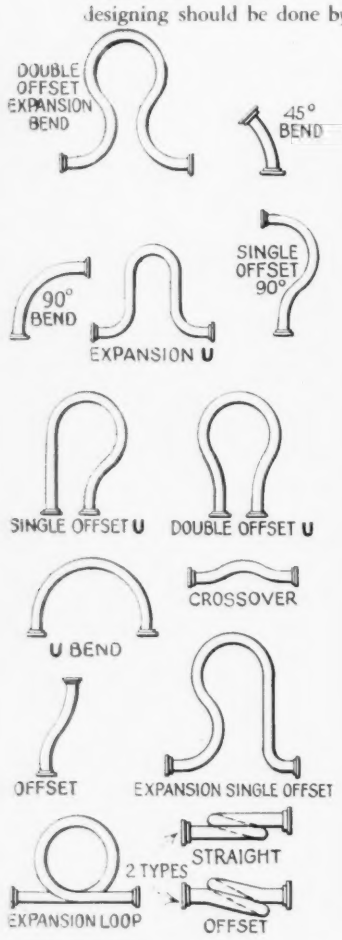
| Size of Pipe Inches | Mean Radius of Bend-Inches | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 15 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| 1 | ¼ | ⅜ | ¾ | 1¾ | 3⅜ | ... | ... | ... | .. | ... | ... | ... | .. |
| 2 | ⅛ | ½ | ¾ | 1 | 1¾ | 2¾ | 3⅞ | 5⅜ | ... | ... | ... | ... | .. |
| 2½ | .. | ¼ | ⅜ | ⅞ | 1½ | 2¼ | 3¼ | 4½ | 5¾ | ... | ... | ... | .. |
| 3 | .. | ⅛ | ⅜ | ⅝ | 1⅛ | 1⅞ | 2⅝ | 3⅝ | 4¾ | 6 | ... | ... | .. |
| 3½ | .. | .. | ¼ | ⅝ | 1 | 1⅝ | 2⅜ | 3⅛ | 4⅛ | 5¼ | ... | ... | .. |
| 4 | .. | .. | ¼ | ½ | 1 | 1½ | 2 | 2⅞ | 3¾ | 4¾ | 5¾ | ... | .. |
| 4½ | .. | .. | .. | ½ | ⅞ | 1⅜ | 1⅞ | 2½ | 3⅜ | 4¼ | 5¼ | ... | .. |
| 5 | .. | .. | .. | ⅜ | ¾ | 1⅛ | 1⅝ | 2¼ | 3 | 3¾ | 4⅝ | 5⅝ | .. |

| Size of Pipe Inches | Mean Radius of Bend-Inches | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 15 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| 6 | .. | .. | .. | ⅜ | ⅝ | 1 | 1⅜ | 1⅞ | 2½ | 3⅛ | 3⅞ | 4¾ | 5⅝ |
| 8 | .. | .. | .. | .. | ½ | ¾ | 1 | 1½ | 1⅞ | 2½ | 3 | 3⅝ | 4⅜ |
| 10 | .. | .. | .. | .. | .. | ⅝ | ⅞ | 1⅛ | 1½ | 2 | 2⅜ | 2⅞ | 3½ |
| 12 | .. | .. | .. | .. | .. | .. | ¾ | 1 | 1⅜ | 1⅞ | 2 | 2½ | 2⅞ |
| 14 | .. | .. | .. | .. | .. | .. | .. | ⅞ | 1⅛ | 1⅜ | 1¾ | 2⅛ | 2½ |
| 15 | .. | .. | .. | .. | .. | .. | .. | .. | 1 | 1⅜ | 1⅝ | 2 | 2⅜ |
| 16 | .. | .. | .. | .. | .. | .. | .. | .. | ⅞ | 1¼ | 1½ | 1⅞ | 2¼ |
| 18 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1⅝ | 1⅞ |
| 20 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1¾ |

The expansion values can be multiplied by 2 for "U" bends, by 4 for single offset bends or "Expansion U" bends, and by 5 for double offset bends or circle bends.

### Typical Bends

• THE table above shows expansion cared for by 90-deg. bends with factors for other types shown below. Other bends to pass obstructions or reduce friction, are also included. Usually, 5 to 6 diameters of the pipe make a safe radius, but to secure flexibility the radii of pipe bends should be increased to allowable limits. Pressure and pipe diameter govern minimum wall thickness for bends. Tangents should be provided at bend ends to assure perfect joints and should be 1 to 2 in. longer than pipe diameter. Any of these bends may be produced either creased or straight. Actual designing should be done by a specialist.



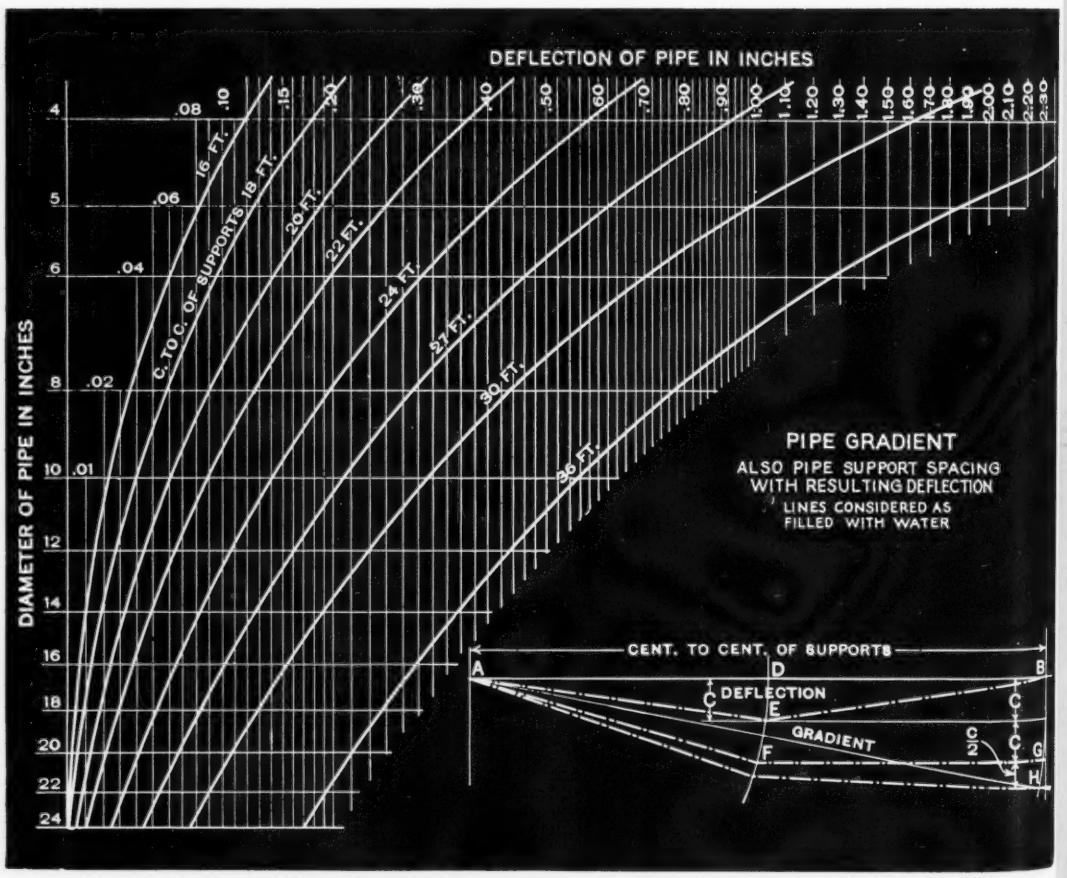

### Pipe Gradient, Support Spacing

• BECAUSE of its own weight, pipe deflects between its points of support. The amount of this deflection or sagging is easily obtained for pipes up to 24 in. diameter and for center-to-center distance between supports of 16 to 36 ft. Pipe is assumed filled with water.

Sagging of pipe between supports forms pockets in which condensate may collect and cause corrosion trouble unless the pipe run is graded sufficiently. The chart can be used to determine the grade necessary to overcome the effect of pipe sag between supports.

*Example:* Find the average gradient and total loss of elevation of a 10-in. dia. standard-weight pipe filled with water, center-to-center of supports 18 ft., line 200 ft. long. No valves or fittings.

Chart shows deflection to be 0.04 in. In the diagram at right of chart *AEB* is the deflected horizontal pipe, *C* is the deflection. If end *B* is lowered to *HA*, distance equal to $2\,C + \frac{C}{2}$, a gradient is established that permits complete draining. In the example $HA = (0.04 \times 2) + \frac{0.04}{2} = 0.1$ in. fall in 18 ft. In 200 ft., total fall is $\frac{200}{18} \times 0.1 = 1.1$ in.






Data courtesy Crane Co. and Nat'l Valve & Mfg.

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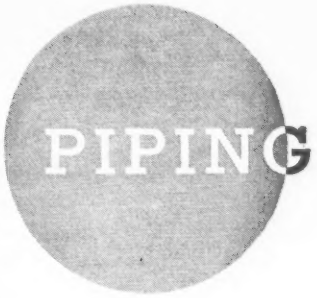
# —FOR BUILDINGS




BUILDING piping differs materially from power-plant piping in that repairs or the correcting of faults is likely to be very costly, since to the normal cost of materal and labor to repair the pipe must often be added the expense of tearing down and restoring building walls and decoration. Thus it is of utmost importance to select as nearly as possible pipe material that will last the life of the building. No general specification can be given for this, as water conditions vary from city to city, and in selecting pipe material it is safer to go by the experience of others in the same locality than by water analysis. Most severe service is usually encountered in service hot-water lines, heater drips and heating system returns. Brass pipe, wrought iron pipe, steel pipe and cast-iron pipe all have their legitimate places in practically all important buildings.

In laying out heating systems, particular attention should be given to zoning. The system should be sectionalized not only to take care of the different wind, sun and temperature conditions on the four sides of the building, but also to take care of differences in occupancy. An ideal system would permit supplying steam at night only to those floors that are occupied. Such an arrangement, however, would be too costly and can usually only be approximated.

In buildings supplied with high-pressure steam, careful attention should be given to the selection of reducing valves and the layout of the reducing-valve station. If valve sizes are incorrectly chosen for the steam flow, the installation is likely to be noisy. Two parallel sets of valves are often required, one to take care of winter conditions and a smaller one for summer conditions. Reducing valves are often bypassed to permit repair without the necessity of shutting off steam. A relief valve should be installed on the low-pressure side to prevent dangerous pressures on low-pressure piping.

As in all steam piping, provision must be made for pipe expansion which in heating systems normally amounts to about $1\frac{1}{2}$ in. per 100 ft. Expansion joints or pipe bends should be provided to take care of expansion in risers or downcomers in buildings of more than four stories. Main headers are usually anchored at one point and allowed to expand freely. Radiator branches from risers should be long enough to permit vertical movement of the riser without straining the fittings. A 6-ft. branch will take care of the expansion in a 35- to 40-ft. riser.

Pockets should be avoided in both supply and return lines. They make for noisy and sluggish systems. Supply branches from horizontal mains are best taken from the top half of the pipe at 45 deg. Mains and branches should be graded 1 in. in 20 ft. when condensate flows in the direction of steam flow and doubled when flow is in opposite direction.

The heels of all risers should be trapped and provided with dirt pockets.

Minimum capacities of supply and return risers for both 1- and 2-pipe systems are given in the 1927-28-30 A.S.H.V.E. *Transactions*. Wet return mains are usually proportioned so that a 1-in. head of water will produce required flow. In proportioning any system, remember that steam flow when heating a cold system is at least double the normal flow.

*Bibliography—Mechanical Equipment of Buildings*, Harding & Willard; A.S.H.V.E. *Guide*.

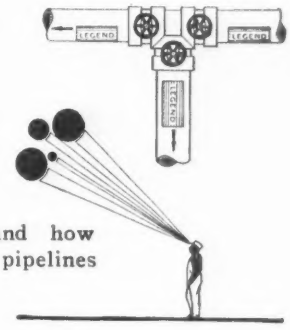
# —SYSTEM IDENTIFICATION

COMPLEX piping systems in modern industrial plants transmit not only steam and water, but dangerous and valuable fluids. In central stations, piping systems are exceedingly complex. In either type of plant some system of identification is worthwhile for ordinary repairs and operation, but in emergency it is invaluable.

Two general color schemes have been published, the first adapted to power houses themselves, the second for general industrial piping. An A.S.M.E. Committee has suggested the following colors, to be painted on valves, flanges and fittings only, the piping itself to be painted to suit the general color scheme: High-pressure steam—white, exhaust steam—buff, l.-p. fresh water—blue, h.-p. boiler feed lines—blue and white, salt water—green, oil—brass or bronze yellow, fuel oil—black, air—gray, city gas (for lighting, etc.) aluminum, gas for engines—black with red flanges, refrigerating system—black pipe with alternating white and green stripes on flanges and fittings, electric lines and feeders black pipe with alternate black and red stripes on the flanges.

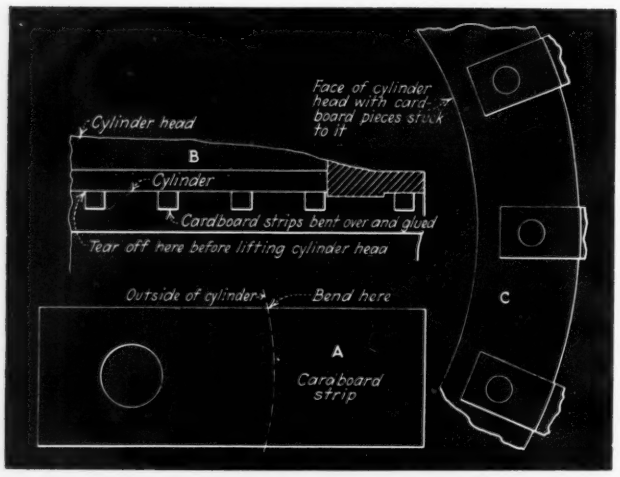
American Engineering Standards Committee suggests five general classes of piping: Class F—Fire protection, including sprinkler systems—red; Class D—Dangerous materials—yellow, Class S—safe, cheap materials—green (or achromatic colors such as white, black, gray or aluminum), Class P—Protective materials—bright blue; Class V—valuable materials—deep purple. These are also painted in bands at conspicuous places preferably near valves and fittings. Details in A.E.S.C. Report A-13.

With either system, lines can be further identified by stenciling legends over or beside color bands in such a position that they can be read from place where operator is likely to stand when trying to identify them. When view is unobstructed, legend should be repeated on both lower quarters of pipe if overhead, both upper quarters if below operator's line of vision.




Where and how to mark pipelines

# PRACTICAL AIDS TO OPERATION




## Transfers Holes from Cylinder to Cylinder Head

RECENTLY, I had the job of transferring 24 blind stud holes to a cylinder head. How others would do this without a complicated marking off process I don't know but I used a method that seems novel and practical enough to warrant attention. I cut 24 pieces of cardboard about $1\frac{3}{4}$ in. wide by 4.5 in. long, as at *A* in the figure, then punched a hole in each piece the same size as the tapped holes in the cylinder. One of these pieces was lined up over each hole and glued to the side of the cylinder.

Next, glue was spread over the face of each cardboard piece around the hole. The new blank cylinder head was then carefully put into place, as at *B*. When the glue was dry on the cylinder head, I released the cardboard strips from the side of the cylinder. Thus, when the cylinder was lifted, the 24 pieces of cardboard were stuck to it as at *C*, with the holes in the exact position of the tapped holes in the cylinder. A center punch mark in the center of these holes made the head ready for drilling, the cardboard being left in place as a guide to the drill.

*Hamilton, Ont.* H. MOORE

## Make Sure of Induction Motor Bearings

INDUCTION motors sometimes give trouble due to slow speed, heating of windings, noisy operation—even in some cases fail to start. Not infrequently these difficulties are attributed to winding faults when the trouble is worn bearings. Air-gap clearance between rotor and stator of some induction motors is close so that a small amount of wear will let the rotor in contact with the stator. The amount that the shaft can be moved in the bearings may be so small that it appears they are not at fault.

Frequently, when the motor is disconnected the rotor can be turned freely in its bearings by hand, indicating that it does not rub the stator. True, it does not, but when power is applied to the stator, unbalanced magnet pull on the rotor springs the shaft sufficiently to bring the rotor in contact with the stator. The oil film in the bearing is also a factor. When the rotor is turned by hand, bearing load is light and oil film thicker than when the motor is energized and bearing loads are heavy due to rotor unbalanced magnetic pull.

In some cases the motor will start at one time and will not at others, but can be made to start by rotating the rotor part of a turn. This action is very likely caused by a slight eccentricity of the rotor core. If the rotor stops where it is closest to or in actual contact with the stator core, it will not start. In this case, unbalanced magnetic pull actually brings the rotor into firm contact with the stator. If the rotor stops with its shortest radius on the low side of the bearings, the air-gap clearance is sufficient to allow the rotor to start and it will come up to speed.

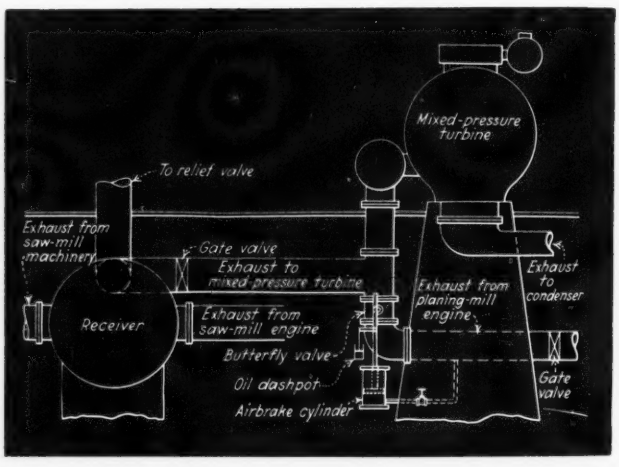
It has been my experience that these facts are not as generally known to maintenance men as they should be. In several cases I have been called in on induction motor troubles where windings had been renewed to correct supposed winding troubles when the bearings were at fault. Of course, a new winding did not correct the trouble. In other cases I have seen the starting winding burned out of split-phase motors because bearings were worn and the rotor rubbed the stator, preventing the motor from attaining sufficient speed to cut out the starting winding. Motors have been operated with the rotor rubbing the stator and caused sufficient vibration to destroy the winding insulation before anything was done to correct the fault.

When an induction motor gives indications of unsatisfactory performance, make sure that the bearings are not at fault before checking other conditions, otherwise a lot of unnecessary work and expense may be incurred.

*Philadelphia, Pa.* R. M. STEVENS

## Automatic Valve Controls Exhaust Pressure

A 600-HP. mixed-pressure turbine-generator in our plant supplies power to the town, a planing mill that is partly electrified and for other purposes. Low-pressure steam for the turbine comes from a large corliss engine and other steam-using devices in the sawmill. One year we had to shut the sawmill down all winter; this required operating the turbine



on high-pressure steam only. A large corliss engine used to drive part of the planing mill about 300 ft. from the power plant exhausted to atmosphere, and it was decided to pipe this steam into the turbine.

Load on the planing-mill engine ranges from zero to 500 hp. With light loads on the engine, we found that exhaust steam was not sufficient to maintain a positive pressure in the exhaust line, and vacuum from the condenser would extend back through the turbine to the engine. As this engine was adjusted to operate against back pressure, a vacuum caused unsatisfactory performance.

We installed a gate valve in the exhaust line near the turbine. By closing this valve partly to hold back pressure on the engine we could operate satisfactorily, but it required constant attention. We needed an automatic valve to maintain pressure on the engine slightly above atmosphere, so I proceeded to develop such a device.

The general arrangement of this valve and its operating equipment are shown. To obtain a valve of low operating friction, I selected a butterfly type to be operated by a small steam cylinder. An 8x8-in. airbrake cylinder was used for the power unit to operate the valve. The valve was made from a short length of pipe on which two old stuffing boxes were welded for the valve shaft. A disk for the valve was cut from a piece of flat steel and welded to the shaft after it was in place. The operating cylinder was connected to the valve shaft by a rack and pinion and its motion dampened with an oil dashpot.

This equipment, although made from odds and ends picked up around the plant, operates very satisfactorily. When sufficient exhaust is available, the pressure acting on the operating-cylinder piston opens the butterfly valve. As exhaust pressure decreases when the load drops off the engine, the butterfly valve is closed by a weight, to maintain pressure in the exhaust line.

*Libby, Mont.* F. E. BATEMAN

## Synchronizing a Small Hydro Generator

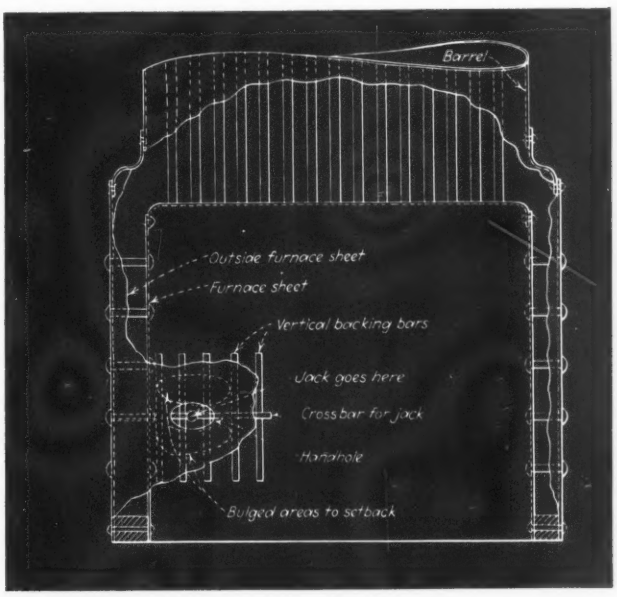
OPERATING engineers, through experience, are able to parallel alternating-current generators without causing serious disturbances in the power system. Waterwheel generators, even of small size, have considerable inertia, and if connected to the system even when a small amount off-phase they may cause an objectionable power surge. Usually, rules for synchronizing instruct operators to close the switch when the synchroscope needle points to zero. This is all very well, but in the case of a waterwheel generator it makes considerable difference in the disturbance if the machine is running slightly slower or faster than the power system, when the switch is closed. It is almost impossible to keep a small unit exactly to speed with the system, especially if it is regulated by operating the gates manually. If the switch is thrown when the generator is increasing in speed, the synchroscope showing slow, the unit will go on the line and cause very little disturbance. If, however, the switch is closed when the wheel is running above speed, there is likely to be a serious surge. It is therefore always advisable to synchronize when the speed is increasing rather than decreasing. After the machines are once together, the gates can be opened until the generator takes the proper load.

In most cases where a small unit is connected to the system, the gates can be opened to let the generaotr take full load, and the system will take the variations. It is not necessary to use a governor on such a unit, as speed will be automatically taken care of by the other units. On some systems it might be advisable to keep the wheel from running away should it become disconnected accidentally. When the machine is to be shut down, it is only necessary to close the gates until the load shows approximately zero, then open the switch.

*Waterloo, Wis.* K. B. HUMPHREY

## Repairs Bulged Furnace Sheet

MANY plant engineers who have had charge of vertical fire-tube boilers have had experience with furnace sheet bulges. While there is no excuse for this, a competent engineer may take charge of a plant where care has been lacking and may be faced with a job of repairing one of these furnace sheets. These bulges are usually caused by heavy accumulations of scale in the water leg. This type of boiler should be




thoroughly washed out at regular intervals to prevent scale accumulation.

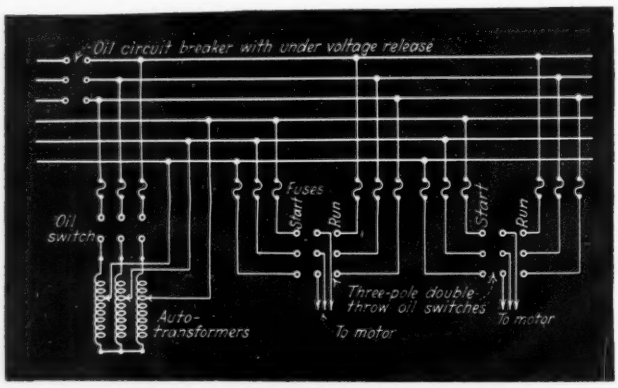
A method of repairing this trouble is to procure three to five pieces of square steel stock, each about $1\frac{1}{4}$x$1\frac{1}{4}$x12 in. long. Next, a handhole opening is cut on the outside furnace sheet, as nearly as possible opposite the bulged section. The handhole edge should be preferably at least an inch from the nearest staybolt. If a handhole opening is already at or close to this location, a new one will be unnecessary.

Such bulges are usually between two horizontal rows of staybolts and less frequently between more than two rows. Staybolts in the defective area should be removed and the 12-in. pieces of steel placed vertically against the furnace sheet. A piece of $1\frac{1}{2}$-in. square by 12-in. steel stock is placed horizontally across the middle of the vertical pieces. This horizontal piece should be bent to the curvature of the furnace sheet. A jack is then placed between this horizontal piece and some rigid outside support, and put under sufficient pressure to hold the cross pieces tightly against the furnace sheet.

A man inside of the furnace then heats the sheet just

enough so that the metal can be shaped by moderate blows by a short-handled, 4- to 6-lb. sledge. By using care to start at the bulged-area outside and working towards the center with decreasing circles, a satisfactory repair job should be obtained. Steel braces held in back of the sheet by the jack help shape the sheet to its original curvature. The staybolts are then renewed and a handhole plate placed in the opening. Such repairs are best made by a competent boiler shop man.

*Boston, Mass.* HARRY M. SPRING, JR.




## Starts Group of Motors With Single Auto-Transformer

RECENTLY I had the job of installing several closely grouped squirrel-cage motors that were to be started consecutively from one location by one man. After considering the advantages of installing a compensator on each motor for starting, or starting the group from a single auto-transformer, I decided in favor of the latter. The diagram shows the connections. An auto-transformer of sufficient capacity to start the largest motor was selected and connected as shown. All oil switches and the auto-transformer were grouped on one switchboard. Experience with this installation has shown it to be safe, convenient, and easy to maintain.

*Cleveland, O.* CHARLES A. ARMSTRONG

## Explosion in Coal-Pulverizing Plant

A SERIOUS coal-dust explosion occurred at a pulverized-fuel plant, resulting in severe damage to the plant and injury to six workmen. Warm air entered at the grinding-mill bottom. Coal when ground was removed from the mill by a fan and discharged into a small cyclone, from which it dropped into a large hopper. A day before the explosion occurred, a fire in a raw-coal hopper had forced it to be emptied.

After the mill was restarted, an explosion occurred in the pulverized-coal hopper that blew the top off. The explosion was thought to be caused by overheating of a pocket of coal dust in one of the pipes which ignited the dust cloud blown into the almost empty hopper. A safety vent had been placed on the cyclone above the hopper, but this was not sufficiently large to relieve the pressure due to the explosion. After this accident, a safety vent was fixed to the hopper itself and also one on the mill. It is believed that if the pulverized-coal equipment had been properly provided with these devices before the accident, the explosion pressure would have been relieved and little or no damage would have been done.

*Bromley, England* W. E. WARNER

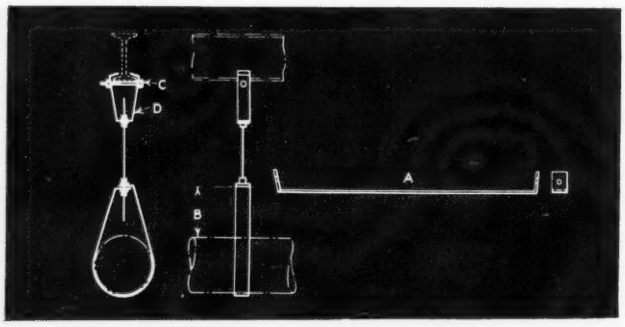
## Maintain Generator Bearing Pedestal Insulation

WHEN generator bearing pedestals are insulated from the bedplate, this insulation must be properly maintained. Insulating the pedestal prevents circulating currents from passing along the rotor shaft, down through one bearing pedestal to the bedplate, and up through the opposite pedestal to the shaft. Where such currents exist, severe pitting of the bearing metal is sometimes experienced. Currents passing through the oil film between bearing metal and shaft tend to darken the oil, increase its acidity, and cause deposits.

A short length of wire affords a simple means of checking pedestal insulation. Make electrical contact with one end of the wire on the pedestal and hold the other end against the shaft end. If sparking occurs, the pedestal insulation is bad and should be repaired. If sparking does not occur, the pedestal is sufficiently well insulated to avoid circulating current. Making connection between bedplate and shaft will indicate by sparking presence of a circulating-current potential in the shaft.

In most cases, failure of pedestal insulation results from ignorance of its purpose. When the generator is inspected or repaired, insulating sleeves and washers are often removed from the baseplate and oil-line flange bolts. Insulating material between the pedestal and baseplate is sometimes replaced with metal by over-diligent mechanics anxious to perform a good job of shimming. Where direct-connected exciters are used, it is necessary that all pedestals on the outboard end of the generator be insulated if circulating currents are present.

*Waynesboro, Va.* S. H. COLEMAN




## Easily Made Beam-Clamp Pipe Hanger

TO OVERCOME objections to the conventional type of pipe hangers, I developed the design shown in the figure. The flange width of standard I-beams varies from 2.66 in. on a 4-in. size to 7 in. on a 24-in. size. Figuring on about 1.5-in. adjustment on the bolt *C* fastening clip *D* to the I-beam, three sizes of clips and bolt can be made to fit almost any size of standard I-beam or ordinary plate girder.

The pipe bands are stocked in shapes at *A* and 30 in. long, which can be shaped as carriers for standard pipes 3 to 8 in. in diameter. Distance *B* is approximately 12 in. for a 3-in. pipe and 5½ in. for an 8-in. pipe. The hanger rod may have 6 in. of standard thread on each end, and adjustments are made at the beam clamp and pipe carrier. Two nuts and washers, one on each side of the hanger, lock the hanger-rods effectively. Shaping of pipe carriers from stock strips may be done in the field to fit various size pipes.

*Pittsburgh, Pa.* BERNARD KRAMER

# CURRENT COMMENT

## Distance Gage For Liquid Level

IN the December (1934) POWER is an article, "Distance Gage for Liquid Level" that criticizes the formulas used in computing the dimensions of the gage described by me in *August* (1934) number. I wish to acknowledge the error in the formula for finding the bore of the mercury wells $D_1$. The correction factor $AD_2$ divided by $d$, which is given for the difference in level of mercury legs at zero gage $M$ is impractical to use.

When filling the gage after it is set up complete the valve on the line leading from the oil tank is closed and the plug removed from the tee on top of the lower cylinder. The lower cylinder is then poured full of mercury, which of course partly fills the tube connecting the two cylinders. If this connecting tube is of small bore and "plus at least one half inch," included in the formula for the height of the mercury wells, is added to the depth of the wells then when the plug is replaced and the valve opened the mercury rises into the upper cylinder there will still be enough left in the lower cylinder to cover the required range of travel. With the tank standing empty, red oil is then poured into top of the gage glass until it reaches the zero mark. The gage is then calibrated by varying the level of oil in the tank, or if this is not possible, an Orsat leveling bottle may be used.

It will be seen from this procedure that the exact level of the mercury at zero reading cannot be known, therefore the distance $A$ will be indefinite. This negligible amount is taken care of in the "plus at least one half inch" included in the formula. In the article in the December number it is figured that without the correction, $M$ would equal 20.8 and with it would equal 20.14.

In building this gage, some leeway must be allowed, especially as regards gage glasses as these are of varying inside diameters and difficult to measure accurately. I have, since making the first gage, made two more for measuring water level in hot and cold wells where the gage glass is located above the water level and with the U-tube down in the wells. Both of these are very satisfactory.

*Kansas City, Kan.* ROY EMISON

## Boiler Tube Replaced in Two Sections

I WISH to comment upon the article "Boiler Tube Replaced in Two Sections," by H. M. Spring, in *December* POWER. Some conditions discussed in this article appear to be opposite to what they actually are. In the first place, it seems to me that it would take an extra-heavy boiler tube to give enough material for the threaded joint. As I have read the Boiler Codes, it appears that only No. 8 gage is given in its tables for a 4-in. tube, a size one might expect to find in the average horizontal-tubular boiler. Therefore, where is the necessary thickness in order not to weaken the tube at this point? I am also wondering if such a method of repair would meet the requirements of the A.S.M.E. Code.

Beading of the tubes was apparently made for the purpose of preventing the plates from separating at the sections. I cannot understand this, because pressure is in opposite directions and the beading of the tubes is of no avail as far as separation of the two sections is concerned. Beading is not for the purpose outlined, for as I understand it the Code does not figure any strength is assumed to be gained by beading the tubes.

*Binghamton, N. Y.* CHARLES W. CARTER, JR.

I HAVE read Charles W. Carter's comments on replacing a boiler tube in two sections. I still, however, maintain that a tube in an horizontal-tubular boiler can be and has been installed in two sections under certain conditions, as described in *December* POWER. I have discussed this with several boiler inspectors and engineers and find that they are of the same opinion.

While boiler rooms are generally designed to allow tube replacements, there are a few in which this is impossible without tearing a wall down. In these instances, where one or two tubes are in bad condition, they may be plugged at the tube sheets. If they must be renewed, then the only way in which it can be done, without tearing out the wall, is by the method described. To insure that the threaded joint will remain tight it should be made with iron cement of a grade that hardens with heat. After the joint is made, the cement should be set by careful use of a blowtorch, taking care not to overheat the tubes.

As for the strength of the joint, it must be considered that this is under collapsing pressure. I wonder if Mr. Carter knows how nipples between the decks of a double-deck B. & W. boiler are put in. These nipples, connecting the upper and lower sinuous headers, are in many installations too long to be put in through the handhole in one piece. So they are cut in two and put in, one-half from the top header and the other half from the bottom, then threaded together. Usually a coupling is used, but I have seen them recessed and threaded in a manner similar to that which I suggested for a fire tube. These nipples are exposed to the products of combustion, they are under a bursting and not collapsing stress, and are under a considerable tensile stress, having to take their share of the weight of the lower header. I have seen but very few cases where leakage developed at this point.

In the horizontal-tubular boiler the area exposed to pressure between the tubes is very small as compared with the segments which require bracing. It is true that the tubes must support this area, and for that reason I particularly pointed out that such a repair was suggested for one or two tubes only. Assuming the holding power of a tube so repaired is zero and the spacing of the tubes is 4 in. from the edge of tube holes; an area enclosed by a line drawn 2 in. away from the tubes is considered self-supporting by most codes. So I think that it may be understood that such an area about one tube does not require bracing.

Mr. Carter is correct when he points out that no appreciable strength is gained by beading. This is not the idea I intended to convey, but that beading would prevent the tube from turning after the threaded connection is screwed up tight.

*Brookline, Mass.* HARRY M. SPRING, JR.

# PERMISSIBLE OVERLOADS FOR TRANSFORMERS

**Results of studies made to determine life of transformer insulation under various operating conditions, and short-time overload that may be permitted without danger of seriously injuring winding insulation**

ONE session of the American Institute of Electrical Engineers' Convention, held at the Engineering Societies Building, New York, N. Y., Jan. 22-24, is of particular interest to power engineers. At this a symposium was presented on transformers. Two papers dealt with work being done to establish permissible short-time overloads on this equipment.

The American Institute of Electrical Engineers' Transformer Subcommittee plans to extend the Institute publication on operation of transformers to include recommendations for short-time overload of oil-immersed transformers in service. These recommendations take advantage of heat-storage capacity of transformer material to supplement present recommendations relating to continuous overloading that is possible when ambient temperature is below standard. This report, by V. M. Montsinger and W. M. Dann, gives considerations upon which the proposed changes are based.

For some time A.I.E.E. Standards have recognized three limits of winding temperature corresponding to three different time periods. These temperature limits are 95 deg. C. for continuous operation, 160 deg. C. for 1-min. operation, and 250 deg. C. for 5 sec. and less. Having these three established standards, all verified by years of successful operating experience, temperature limits, Table I, for short-time overloads were set up.

Laboratory research showed that the rate of mechanical deterioration of fibrous insulation doubles approximately for each 8-deg. C. increase in temperature and approximately halves for each 8-deg. C. decrease in temperature. Limits in the table have been chosen to give a wholesome degree of conservatism, which is warranted when establishing general rules for overloading transformers.

Steady safe-temperature conditions at beginning of overload have an important bearing on permissible overload. For this reason, two different steady safe-temperature conditions have been recognized, one for full-load, and the other for no-load operation with excitation applied.

Self-cooled, oil-immersed power transformers may be operated at specific overloads for limited periods as given in Table II. Overload values contained in the table are expressed in multiples of transformer continuous rating, that is, the figure 25 indicates a load of 25 times continuous rating.

For permitted load in columns headed, "Following full load," it is understood that, prior to the overload, the transformer has operated at continuous rated load, and at an ambient temperature of 40 deg. C. for a period long enough to establish steady-temperature conditions.

For permitted load in the column headed, "Following no load," it is understood that prior to overload the transformer has been under normal excitation with an ambient temperature of 40-deg. C., but without load current, for a period long enough to establish steady-temperature conditions.

The short-time load of Table II should be reduced 2 per cent of continuous self-cooled ratings below recommended load for each degree that the cooling-air temperature exceeds 40 deg. C. Self-cooled oil-immersed transformers in cooling air, exceeding 50 deg. C., are considered special. Short-time loads of Table II may be increased 1 per cent of continuous self-cooled rating for each degree ambient air temperature is below 30 deg. C., except no further increases are to be made for air temperatures lower than 0 deg. C.

Permissible short-time overloads for oil-immersed transformers of types other than self-cooled are not yet available.

Effects of overloading on the life of oil-immersed self-cooled power transformers were discussed in, "Effects of Overloads on Transformer Life," by L. C. Nichols. Most transformers are single rated 50-deg. rise and good for operation at an ambient temperature of 40 deg. C. This means that their hot-spot temperature is 105 deg. C. Present rules of the A.I.E.E. indicate that a reasonable long life of 15 to 20 yr. can be obtained if transformers are operated continuously at that temperature. According to Mr. Nichols, this is not true. Tests were made by placing different kinds of insulating material in oil for a period of five years, at a temperature of 90 deg. C. At the end of that time the material was exceedingly brittle. A transformer with insulation in that condition would fail if there were any movement of its coils. Tests have also been made on insulation for short periods and at much higher temperatures. Transformers operated at 100 percent load, and ambient temperatures approximating 40 deg. C. have failed due to insulation deterioration after comparatively short periods.

The curves show life that can be expected from transformer insulation when operated continuously at any given hot-spot temperature. They indicate if a transformer operates continuously at a hot-spot temperature of 105 deg. C., its insulation would have a life of only $1\frac{1}{3}$ years. In order to be reasonably safe, if the temperature exceeds 105 deg. C., the expected life is divided by a factor varying from 1 at 105 deg. to 10 at 250 deg. Suppose a transformer is operated with a hot-spot temperature of 150 deg. for four hours. The curves show a life of 240 hr. but a factor of safety of 2.6 must be used. Therefore, when operated for four hours at 150 deg., one operation has consumed $100 \times (4 \div 240) \times 2.6 = 4.3$ per cent of the life. By means of this chart, if the time of operation at a given temperature is known, then the per cent life used can be calculated.

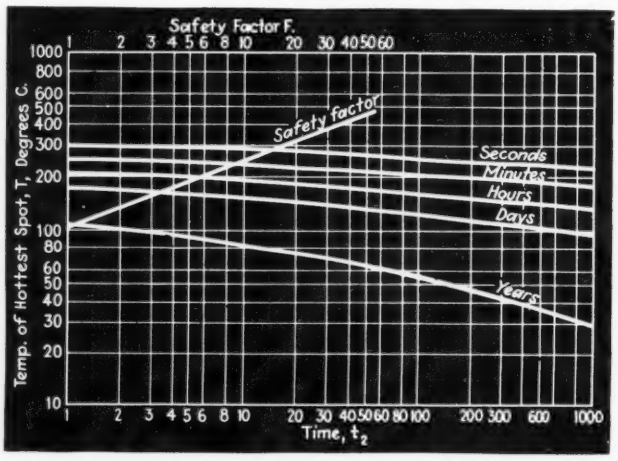
**TABLE I—TEMPERATURE LIMIT**
for Short-Time Loading of Power Transformers

| Time | Winding Temp. Limit, Deg. F | Time | Winding Temp. Limit, Deg. F |
|---|---|---|---|
| Less than..... | ..... | 5 min. | 140 |
| 5 sec..... | 250 | 30 min. | 120 |
| 30 sec..... | 180 | 2 hr. | 105 |
| 60 sec..... | 160 | Contin. | 95 |

**TABLE II—PERMISSIBLE SHORT-TIME LOADS**
for Self-Cooled Power Transformers

| | Ambient Temp. 40 Deg. C | | | |
|---|---|---|---|---|
| Duration of Load | Emergency Loads Following Full Load | Emergency Loads Following No Load | Recurrent Loads Following Full Load | Recurrent Loads Following No Load |
| 2 sec.... | 25 | 25 | 6.5 | 13 |
| 5 sec.... | 14 | 16 | 4 | 8 |
| 10 sec.... | 9 | 10.5 | 3 | 6 |
| 30 sec.... | 5 | 6 | 2.2 | 4 |
| 60 sec.... | 3.7 | 4.7 | 1.6 | 3.25 |
| 5 min... | 2.3 | 3 | 1.25 | 2.1 |
| 30 min... | 1.6 | 1.9 | 1.1 | 1.45 |
| 2 hr..... | 1.25 | 1.4 | 1.0 | 1.2 |

Life of transformer insulation based on hot-spot temperature




Per cent of life used, $L = 100(t_1 \div t_2)\ F$, where $t_1$ = time operated at hot-spot temperature $T$; $t_2$ = life of insulation at temperature $T$; and $F$ = safety factor

# THE ENGINEER'S BOOKSHELF

## Diesel Design

DIESEL ENGINE DESIGN (1935)—*By Harold F. Shepherd, consulting engineer. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 227 pages, 5¾ x 9 in. Cloth. 145 diagrams. Price $3.50.*

This technical text by a regular contributor to *Power* is basically a sound exposition of the various ways of converting petroleum fuel into power by the compression-ignition method. Eminently fair, the book also discusses the relative merits of diesel designs and types with those of other prime movers.

Probably the best way to give an adequate conception of the contents of the book is to list titles of principal chapters, which are: Historical; Combustion; Influence of Combustion Chamber Walls; Fuel Nozzle; Fuel Pump; Governing; Cylinder Heads, Valves and Valve Gear; Starting; Two-Cycle Engines; Injection of Gaseous Fuel; Bearings and Lubrication—Pistons and Piston Rings; The Indicator Diagram; Inertia of Reciprocating Parts and Balancing; Flywheel; Crankshaft; Reducing Calculations in Designing Crankshaft Members (appendix).

Methods of calculation adopted are the simplest and easiest to use and remember. Drawings are large and clear, expositions plain, and treatment good from an engineering standpoint.

## A.S.T.M. Tentative Standards

BOOK OF A.S.T.M. TENTATIVE STANDARDS (1934)—*Published by American Society of Testing Materials, 260 Broad St., Philadelphia, Pa. 1257 pages, 6 x 9 in. Illustrated. Price to non-members $7 paper binding, $8 cloth binding.*

These tentative A.S.T.M. Standards contain 236 tentative specifications, methods of testing, definitions of terms and recommended practices covering materials of engineering and allied testing fields. Of these 236 tentative standards, 25 relate to ferrous metals; 25 to non-ferrous metals; 48 apply to cementitious, ceramic, concrete and masonry materials; 127 cover miscellaneous materials such as paint, petroleum, insulation, textiles, etc.; while 11 are general testing methods applying to these materials. Proposed revisions of standards are also included, published as tentative with a view of eliciting criticism, of which the committees concerned promise to take due cognizance before recommending final action.

## Chem. Power Plants

CHEMICAL ENGINEERING PLANT DESIGN (1934)—*By Dr. Frank C. Vilbrandt, professor of chemical engineering, Iowa State College. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., N. Y. C. 341 pages, 6 x 9½ in. Cloth covers. 53 diagrams, 95 tables; 4 appendixes. Price $4.*

An analytical presentation of fundamental principles and factors involved in design of a complete chemical plant. This volume of necessity discusses power and power transmission equipment. Chapters of particular interest to the power engineer include: Piping Installation, 25 pages; Pumps and Pumping, 23 pages; Power and Power Transmission, 17 pages. Odd parts of other chapters are also of interest in their explanation of the interrelation between power and process equipment. The appendixes dealing with preconstruction cost records and data, general tables, and elementary problems are worthwhile, both for examples and for that occasional "brushing up" that never hurts anyone.

## Compressed Air

COMPRESSED AIR DATA (*4th Edition*)—*Edited by F. W. O'Neil, assisted by technical staff, Ingersoll-Rand Co. Published by Compressed Air Magazine, Bowling Green Building, New York, N. Y., 394 pages, 4½ x 7 in. Flexible binding. 51 tables, 122 illustrations. Price $3.*

Compressed-air applications have a part in practically all industries and this handbook was compiled with that in mind. This, the fourth edition, has been revised and enlarged to bring the data up to date and make it more convenient to use. The material is arranged in 13 chapters: terminology and definitions; theoretical; compressing air; booster and vacuum pumps; turbo or centrifugal blowers and compressors; tables of data; intake air, aftercooling, intercooling, reheating; cost of compressed air; pumping with air; gas compression; installation of compressors; belting; application and performance; measurement of air flow.

Both theoretical and practical phases of compressed air are considered, but the treatment is such as to make the handbook useful to practical workers as well as technically trained engineers. A large part of the theory is confined to Chapter II. Forty tables that would normally be scattered through the book are arranged in one chapter where they are readily available. The chapter on applications and performance lists uses for compressed air in 84 industries. The many features included and their practical treatment make this little book valuable to everyone interested in compressed-air problems.

## Industrial Furnaces

INDUSTRIAL FURNACES, VOL. I, (*3rd Edition*)—*By W. Trinks, professor of mechanical engineering, Carnegie Institute of Technology. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 456 pages, 6 x 9 in. Cloth. Illustrated. Price $6.*

Although "Industrial Furnaces," as its title implies, deals entirely with the construction of furnaces used for industrial processes, much is given that can be used or adapted to boiler furnace construction. About two-thirds of this edition represents entirely new writing and includes the latest data on furnace building.

## Brief Reviews

CHARACTERISTICS OF ITALIAN RIVERS. (1934). *Published by the Hydrographic Service, Minister of Public Works, Italy. 330 pages, 6 x 9 in. Paper. Published in Italian.*—Gives data on all the important rivers and streams in Italy. These include average, maximum and minimum flows, rainfall and runoff during the years 1926 to 1932.

ELECTRICITY (1935). *By L. D. Fourcault. Published by Runod, 92 Rue Bonaparte (VI), Paris, France. 501 pages, 4 x 5½ in. Cloth. Many tables; 121 illustrations; 501 pages. Price 23.8 Fr.*—This is a practical electrician's handbook published in French. It deals with both theory and practice and covers such subjects as signs and symbols for electrical drawings, generation of alternating and direct current, tranmission and distribution of electrical energy, storage batteries, motors and controllers, radio, and codes of practice for installing electrical equipment.

DIFFERENTIAL GEOMETRY (1935). *By Wm. C. Graustein, professor of mathematics, Harvard University. Published by the Macmillan Company, 60 Fifth Ave., New York, N. Y. 230 pages, 5½ x 8½ in. Cloth. 40 diagrams. Price $3.*—An account, in terms of vector notation, of the fundamentals of metric differential geometry of curves and surfaces in a Euclidean space of three dimensions. Suitable for college text or advanced engineering study. Nine chapters of exposition; tenth (and last) applies this theory to important classes of surfaces.

MECHANICAL WORLD YEAR BOOK (1935). *Published by Emmott & Co. Ltd., 31 King St., West, Manchester, England. Price 1/6 net.*—Pocket data book, with new sections on pumps and compressors. Very much mechanical data in concise form.

STRESS DISTRIBUTION IN LONGITUDINAL WELDS AND ADJOINING STRUCTURES (1934). *By William Hovgaard, Mass. Inst. of Technology. Reprinted from the "Journal of Mathematics & Physics," Vol. XIII, No. 2. Obtainable from Engineers Book Shop., 227 Park Ave., New York, N. Y.*—An account of a theoretical and experimental study carried out at M. I. T. from 1930-1933. This is a first step in the comparatively new and extensive field of weld research.

# READERS' PROBLEMS

## QUESTIONS for Our Readers

### SUPERHEATER CIRCULATION

**Question 1**

WE HAVE *6,000-sq.ft. cross-drum water-tube boilers in our plant fired with pulverized coal. Superheaters are behind the 5th row of tubes and give a steam temperature of 650 deg. at 250-lb. pressure. When starting these boilers up from cold, is it necessary to keep the superheater header drains wide open until the boiler is put on the line?—this to produce circulation and prevent overheating the superheater tubes?*—V. D. N.

### ZONED HEATING

**Question 2**

I OPERATE *a zoned heating system in a 30-story building. Steam is distributed from the 17th floor to five zones, two zones for the radiators on the 18th to 30th floors and two zones for the radiators on the 4th to 17th floors. Lower floors are heated from the basement. All radiators have inlet orifices but no return traps. There are two tenants, one on the 8th floor and one on the 22nd floor, that regularly work at night, and to supply heat to these two floors it is necessary to heat almost the entire building at night when otherwise steam would be shut off. If there were some way to supply steam to these two floors alone, very substantial economies could be made. I would greatly appreciate any suggestions from the readers of POWER on how this might be done.*—J. R. M.

Suitable answers to these questions from readers will be paid for if space is available for their publication.

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## BONUS SYSTEMS FOR POWER PLANTS

ANSWERS to December Question 1

### THE QUESTION

WE WOULD *appreciate any information that you can give us on where to secure reprints or copies of articles describing bonus or wage incentive systems for firemen and engineers, where the men receive a bonus based on the efficiency at which they operate. We are particularly interested in a system for firemen operating 5,000-sq.ft. boilers in a small industrial plant having both heating and process steam loads.*—J. W. T.

### Bonus Systems Cause Trouble Among Firemen

THE bonus question is one for which many engineers have tried to find a satisfactory answer. We tried this in several plants and had to abandon it in every case.

Some twenty years ago, I tried the plan of paying firemen a bonus of one cent a hundred pounds of coal saved on each shift. Coal was weighed out to each man and checked against his watch. Result, Fireman No. 1 would allow his fires to run low just before the end of his shift, thus saving a hundred or so pounds. The next man of course had to build his fires up and then would do the same thing on the end of his shift. The total coal saved was practically nil.

Again, on a stoker-fired plant, we tried paying the three firemen a bonus on the tons of coal saved per month. The net result of this after six months was that each man earned some $2.50. They were so dissatisfied that we could not achieve any worthwhile results.

Most firemen, when you offer them a bonus, expect to make a lot of money. When they don't they lose interest and slip back into the old devil-may-care way of doing things. I think the best plan is to pay wages large enough to get good men. If this is done they will take an interest and save coal, material, and time. If they don't better change men and not the reward.

*Wilkes-Barre, Pa.* THOMAS M. STREET

### Bonus Paid For Coal Saved

ANY wage incentive plan for power houses must necessarily be simple and a bit crude, for so many complicated and unmeasurable factors are involved in this type of work. A job cannot be definitely standardized nor each man's reaction under varying stresses catalogued.

All good plans are based on three things: quantity of work, quality of work and economy in use of materials. The plan must be advantageous to both employee and employer. It is also better that rates be figured over a short period of time, else workers will tend to lose interest.

I have seen an individual bonus plan tried in a small institutional plant. A daily chart of evaporation and efficiency for each shift was posted in the boiler room. At the end of the month, the fireman and water tender with the best record were given a bonus of 10%. This method tended to make competition too keen and develop animosity among the firemen. Unless they were carefully watched the outgoing firemen would burn fires down so thinly that the incoming firemen were forced to load the furnaces with green coal to maintain pressure. They even found ways of cheating coal-weighing.

It was finally decided that this plan was more harmful than helpful, so a group bonus plan was worked out and adopted.

The plant was carrying about the same load as it had the previous year and using the same kind of coal. Therefore, the plan was based on pounds of coal saved.

Daily evaporation and efficiency charts were still posted, and in addition the pounds of coal used each day, with the pounds used the same day of the previous year.

At the end of the month, every man who was eligible was paid a bonus depending directly on the amount of coal saved over the same month the previous year.

For example:

Coal used in November, 1932: 1,500,000 lb.
Coal used in November, 1931: 1,800,000 lb.
Per cent saved:

$$\frac{1{,}800{,}000 - 1{,}500{,}000 \times 100}{1{,}800{,}000} = 15.5\%$$

Then, if Fireman "A" had made $100.00 in November, he received a bonus of 15.5% times $100 or $15.50.

Every man in the plant was eligible unless he had been directly responsible for some trouble during the month.

After this plan went into effect, there was a marked improvement. Every man was alert and watchful of the other fellow's work. The turbine operator notified the fireman of a change in load more quickly, the water tender worked harder helping the fireman clean fires, etc. Every man was working toward one objective—to save a pound of coal.

*Greensboro, N. C.* VAN KENYON

### Bonus Based On Equipment Evaporation

J. W. T. certainly has brought up a pithy question, but one that can be solved and the solution applied in a practical manner. There is a crying need of some sort of bonus system in every modern steam generating plant, and the only reason sensible power executives do not adopt some form of bonus for their firemen is because there is such a great difference of opinion and the chance for cheating is so great with most known systems.

My first experiences with bonus systems was the plan of paying bonus on $CO_2$. This was essentially as follows: By tests it was determined that the boiler plant operated at best efficiency when $CO_2$ was kept at 13.5%. The best known make of $CO_2$ recorder was installed and the following schedule arranged: a bonus of 10% of the fireman's wages was paid daily for a $CO_2$ average of 13.0 to 13.5%. A 5% wage bonus was paid for averages ranging from 12.0 to 13.0% $CO_2$. This went along beautifully for a number of months, and after about six months it was noted that all the firemen were making the maximum bonus with $CO_2$ as high as 14.0%. This was all very good for the firemen, but the fuel cost per 1,000 lb. of steam began to mount and I shudder when I think of the money and time that was spent on furnace refractories. The management finally woke up to the fact which

the firemen had long before discovered—that a $CO_2$ recorder only records percentage of $CO_2$ and nothing else. The firemen found that by restricting the excess air to the furnace they could build up their $CO_2$ and also make a wonderful curve on the steam chart, but with a terrific loss of unburned carbon in the form of CO going up the stack. The scheme was abandoned.

My next experience was with a plan to pay a monthly bonus for over-all efficiency. Boiler-house efficiency was determined monthly and a bonus was paid to all the firemen when the combined efficiency exceeded 70%. This was a straight natural-draft stoker-fired plant with no heat-reclaiming equipment, and the bonus was 3% of the fireman's pay for each 1% in excess of 70% over-all efficiency. This did not work so well. Some months the efficiency exceeded 73%, then it would fall as low as 65. The explanation was that the coal was analyzed by an outside laboratory and the B.t.u. value of the coal analysis rose and fell from month to month. This may have been due to the method of sampling the coal, or differences in moisture content or any number of variables. Anyway it was impractical and the plan was given up, because the good, bad, and indifferent firemen were affected alike.

Then the idea was put in effect of paying a bonus on daily evaporation, based on the equivalent evaporation of each fireman. For each tenth of a pound in excess of 7 lb. equivalent evaporation the fireman was paid a wage bonus of 2%. This has proven successful and is still in operation with a few modifications brought about by changes in plant design and modernization.

With this plan, however, the chances for cheating are great, and this phase has to be watched unless all firemen are honest.

Monthly inventories of the coal must be made, the coal scales and meters checked and kept accurate and tamperproof. Most boiler-house operatives are inherently honest, and if the management strives to win their confidence by being fair and constantly on the job to detect any cheating and punish the offender summarily, this plan will work out with a marked degree of success.

Where this plan is in effect, bonuses are being paid regularly to the good firemen and offer an incentive to the poor fireman to improve himself.

*St. Louis, Mo.* A. F. RIEBER

## HOW TO AVOID STICKING COAL

ANSWERS to December Question 2

### THE QUESTION

WE HAVE *experienced considerable difficulty at times with coal sticking up in bins, bunkers and chutes. It has happened with both solid and pulverized coal. Sometimes the cause is fairly obvious—a sharp angle in a chute, a projection or corner into which the coal can pack to start the sticking. Sometimes it simply packs into an arch which stays up when the loose coal beneath flows out. Our methods of handling the trouble have been crude—hammering, pounding and jabbing to restart flow. I am sure that other practical men have had the same trouble, and will wager that some have found more lasting answers. I'd like to know what they are.*

—J. N. D.

### Avoid Wet Coal To Cure Sticking

I ALSO have had considerable trouble with coal sticking in bins, hoppers, etc., and in each and every case the trouble has been wet coal. It could not be sharp angles or other obstructions that check the flow, because if the problem were structural, then the flow would be interrupted at all times. I do not wish to minimize the importance of having all surfaces smooth and all passages streamlined but that has not been the problem in the cases brought to my attention. The broad statement is often made that coal will flow at an angle of 45 deg., but this is true only of dry coal; wet coal will not even flow vertically, that is if it is wet enough and fine enough.

I have solved the problem by seeing to it that wet coal is not dumped into bunkers, if this can be prevented. All cars are inspected as they arrive, and those that seem very wet are not emptied in the bunkers, but are put in yard storage. It pays to take coal from storage and unload it into the bunkers rather than to unload newly arrived cars with coal wetted by rain during transportation or at the point of origin.

The amount of moisture that is tolerable depends on the fineness. In general, screenings and slack coal must have less than ten per cent moisture or it is likely to stick.

*Chicago, Ill.* N. T. PEF

### Size of Coal Influences Sticking

J. N. D. has a problem that is by no means new. Coal has the quality of adhering together and of adhering to surfaces.

Two ways are open to attack the problem. First: When it is possible, the slopes, sizes, and shapes of bunker outlets and of chutes can be proportioned to aid the force of gravity in overcoming the adherent nature of coal. A great deal of mechanical ingenuity has been applied in arranging poke holes, access doors, compressed-air lances and permanent jets. A discussion of them would be too lengthy, but application of the idea is simple to anyone with ingenuity. Second: The adherent quality of the coal may be reduced in many instances by one or more of the following methods. Select and purchase the size of coal which will serve the purpose. Select and purchase the kind of coal which will flow freely. Dry the coal or arrange with your source of supply to furnish coal in as dry a condition as possible.

The first method is more easily applied when buying or building new equipment for a certain grade and kind of coal. In an existing plant, sometimes a chute can be enlarged, or its slope increased. A bin opening possibly can be changed in shape or size to reduce restriction or to let the coal flow more steeply downward. If a bunker is lined it will be helpful to plaster flnish or smooth the surface of the lining near the outlet. In general, rough surfaces and corners should be smoothed out.

The second method deals first with coal size. Screened sizes flow more readily than coal screenings, particularly fine screenings. This is partly because the fine coal carries more moisture and is more dense. Water acts as a slight binder to cause serious sticking and jamming. Regular screened coals are higher priced than screenings. Some plants use mixtures which meet their requirements reasonably well. There are mines that supply special screenings at a small extra cost. These screenings have some or all of the dust removed. The fuel value is improved and the coal flows better than regular screenings. Some kinds of coal, due to their hardness and structure, handle more readily than other kinds screened to the same size. A well-versed coal man can often give valuable suggestions about different coals and their natures. Many times, trouble of this kind has been reduced by the source of supply cooperating to furnish a dry coal. Wet coal flows much less freely than dry coal.

J. N. D. has experienced difficulty with both solid or raw coal and with pulverized coal. Pulverized coal flows quite freely when the free moisture is reduced to about $\frac{1}{2}$ to $1\frac{1}{2}$ per cent. Inherent moisture does not seem to be a factor.

Numerous coal dryers are on the market for drying raw coal and coal being pulverized. Heat used in drying coal is not an added loss since the moisture would absorb heat in the furnace if it were fired with the coal. Power required to pulverize a ton of coal is reduced and the capacity of the mill and feeders are increased when coal is dried either before reaching the mill or when the coal is dried in the mill. Air-drying the coal in the mill has proved more foolproof than raw-coal driers and it will probably be the cheaper equipment to install.

Flue gas has been used successfully in drying coal in mills. It is used to a much wider extent in raw-coal drying. Steam heat elements have been used in raw-coal dryers and in furnishing hot air for drying.

It is well to keep in mind that coal still retains some moisture after drying and pulverizing. This moisture may give trouble in steel storage bins that are not insulated if cold drafts of air sweep the sides of the bins. The cold steel condenses and accumulates moisture from the coal and transmits it to a small quantity of coal on the cold surface. This small quantity of coal becomes very wet and causes serious trouble.

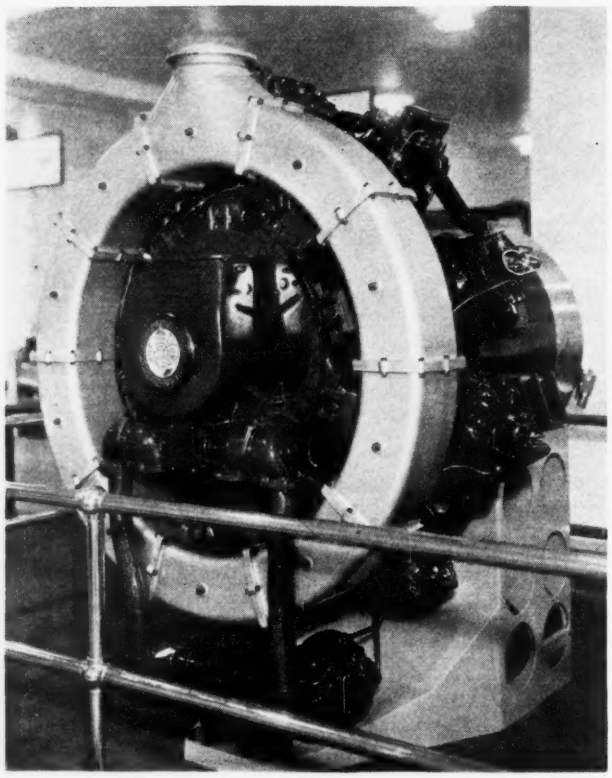
*Harvey, Ill.* CONWAY PIERCE

### Use Hammer To Loosen Sticking Coal

TO OVERCOME sticking coal, install a hammer, air or electric, on the center of your bins. Install in position where it will do the most vibrating. It can be arranged to operate automatically, say every half hour, according to the amount of coal used.

*Oelwein, Iowa* JAMES A. WELCH
*Chief Engineer,*
*City Laundering Co.*

# WHAT'S NEW IN PLANT EQUIPMENT



### 10-CYL. RADIAL DIESEL ENGINE

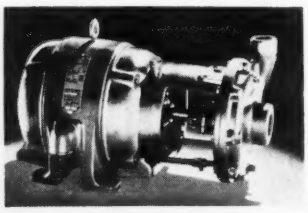
CONTINENTAL 6½ x 7½-in., 2-cycle, 635-hp. @ 1,400-r.p.m. unit is of radial type and weighs but 3,900 lb. complete with accessories, or about 6 lb. per hp. With low-voltage d.c. generator attached, it weighs 9,200 lb., about one-third weight of conventional rail-car type diesels, is only 71 in. in diameter, 41 in. long over-all and 82 in. over-all with generator. Welded Cromansil steel crankcase, and outer ring on which cylinders are bolted is cut 2 in. thick from solid plate. This gives rugged construction in spite of low weight, so unit is also being offered for constant-duty industrial service. Piston velocity about 1,750 f.p.m., but travels within sleeve moving in same direction at 900 f.p.m., making net piston speed about 900. One master piston rod and nine articulated rods, as in aircraft practice. 2-part crankshaft with 2 roller and one ball thrust bearing. Crankpin bearing pressures reach low figure of 800 lb. per sq. in. max. Wrist and knuckle pins have needle bearings. Cylinders nickel-moly iron. Piston and interior cylinder head surfaces flat, with turbulence orifice between combustion chamber and cylinder. Double fuel system of new design using compressibility of fuel to meter quantity of fuel injected. Injection nozzles have four $\frac{0.4}{64}$-in. holes to reduce clogging danger. One fuel system handles even numbered cylinders, other odd. Now using No. 4 furnace oil (24-26 Bé). Ratio of maximum to mean torque 1.1-1, about as good as that of turbine, and torque curve a circle with ten ripples due to overlapping of power impulses. Exceptionally smooth operation. Pressure rise in cylinder 24-25 lb. per deg. of crankshaft rotation, b.m.e.p. 75 lb. per sq.in. Can use 100 lb. with present design. Centrifugal blower (Elliott) supplies scavenging air at 4 lb. pressure, providing 40% excess air for uniflow scavenging. Air enters through circumferential ports at bottom of cylinder, leaves at top. Exhaust temp. 600 deg. F. Fuel consumption first engine 0.45 lb. per b. hp., better expected with refinements.

*Continental Motors Corp., Detroit and Muskegon, Mich.*

### SCALE SOLVENT FOR DIESEL EXHAUST HEADER JACKETS

"ARTJEL" is a special material for cleaning scale from water jackets of diesel exhaust headers. It consists of hydrochloric acid combined with organic inhibitors in such combination that it dissolves scale while suppressing solution or corrosive attack upon metal walls of the header. In a recent test by U. S. Naval Engineering Experiment Station, Annapolis, Md. (Report No. 6164) this cleaner was found to be the only material submitted for test which was suitable for use in cleaning exhaust headers without incurring corrosive attack on metal walls. Manufactured by:

*Artic Chemical & Combustion Engineering Corp., 209-211 King St., Brooklyn, N. Y.*



### MOTORPUMP UNIT

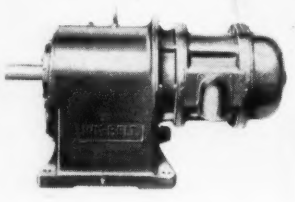
THIS "built-together" motor-pump unit consists of a high efficiency centrifugal side-suction pump with closed bronze impeller mounted directly on shaft of ball-bearing splash-proof motor. Thus there is no flexible coupling and no alignment problem. Shaft runs in ball bearings requiring lubrication only once or twice a year. 10 to 250 g.p.m., heads up to 190 ft., with motors rated ¾ to 10 hp. Bulletin No. 5550.

*Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.*

### MOTORIZED REDUCERS

MOTORIZED helical-gear reducers with high-speed gears and very accessible motors. N.E.M.A. standard round-frame motor secured to side of reducer housing by adapter casting, which supports motor shaft in oversize anti-friction bearings close to pinion, thus assuring alignment and proper meshing of gears. Motor with adapter and pinion may be removed as a unit for inspection or maintenance, without disturbing alignment of gears in housing. Oil seals. For floor, ceiling or wall mounting, double reduction from ½ to 75 hp., ratios up to 38½-1, and triple reduction up to 38 hp. in ratios up to 292-1.

*Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.*



### OIL CLOUD POUR TEST APPARATUS

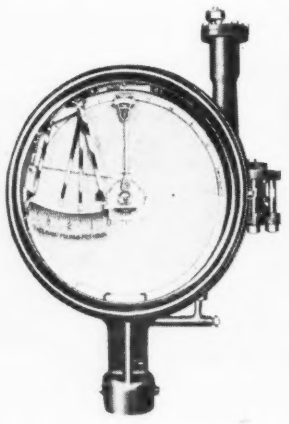
THIS four-compartment "cold-test" apparatus meets latest A.S.T.M. cloud pour test specifications (Serial D-97-34) for lubricating oil, which require at least three, preferably four, baths maintained at these temperatures, 30 to 35, 0 to 5, —30 to —25, —60 to —55. Compartments are copper lined and insulated with 2-in. cork on sides and bottom. In each compartment there is an assembly of four metal jackets mounted on substantial metal tripod, and supporting jars and thermometers. Bulletin No. 1098.

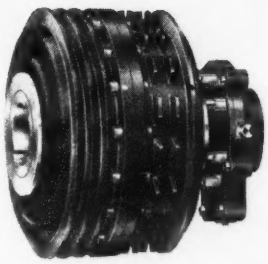
*C. J. Tagliabue Mfg. Co., Park & Nostrand Ave, Brooklyn, N. Y.*

### UNIVERSAL FLOW METER

WIDE, readable flow range and records temperatures and pressures on same chart with flow. All pens move about same center of rotation, but do not interfere with each other. Measures flow of steam, water, air, oil, gas or chemical solutions. Positive zero for ease in checking. Large float gives uniform power from full-scale reading to zero, and unit incorporates straight-line movement which avoids angularity errors. Pressure compensator may be added where necessary. Special trumpet-shaped calibrated mercury chamber gives readings on upper portion of scale magnification of a 100-in. meter, and to those on lower portions magnification of 20-in. meter. Two types, one for pressures to 500-lb. per sq.in.; other for pressures to 1,500 lb. Pressure chambers and U-bend of higher-range meter are forged steel. Can be furnished with transparent eccentric indicating scale and conspicuously colored pointer on pen arm, if desired.

*Foxboro Co., Foxboro, Mass.*





## FRICTION CLUTCH

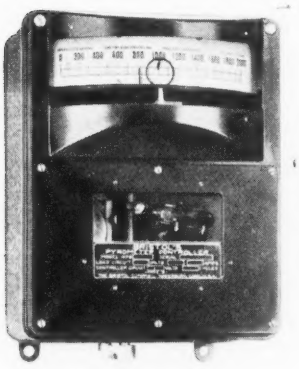
FAST'S friction clutch has coadjustment or self-alignment of rings composing friction element. This automatically distributes pressure uniformly over friction surface, thus increasing power transmission capacity by permitting greater unit pressure. Coadjustment is secured through use of endless or unbroken, highly resilient, conical friction rings, telescoping under wedging action at a mechanical advantage, by means of an axial shifting force whereby outer rings are stretched and inner ones compressed. Smooth action, immediate disengagement, self-locking operating mechanism, one-point adjustment, pre-set safety slip, lubricated, dust and moisture-proof, compact, simple, free from end thrust, interchangeable parts. .Two types, C (coupling clutch) and L (line-shaft clutch), either with duplex or quadruplex friction element. Sizes from $2\frac{1}{4}$-in. to 24-in. bore, with maximum r.p.m. 4,500 to 450. Capacity 5.6 to 4,928 hp. per 100 r.p.m. (dynamic).

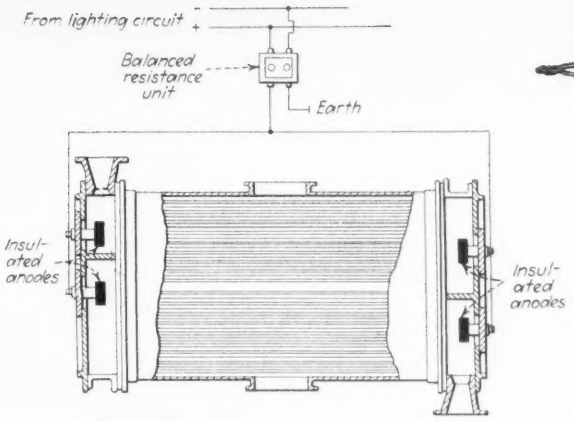
*Gustave Fast Engineering Corp., Annapolis, Md.*

## PYROMETER CONTROLLER

MODEL No. 478 has clean non-arcing, non-oxidizing, mercury-to-mercury electric contact sealed in glass, requires no relay, has visible operating mechanism, accessible Telechron motor, mercury switches and terminal block, which simplifies field inspection without exposing control mechanism to dirt or fumes. Full safety features, accurate control, and heavy working parts.

*Bristol Co., Waterbury, Conn.*





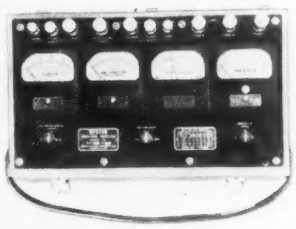

## SCALE ELIMINATION

CUMBERLAND electrolytic system for prevention of corrosion and elimination of scale works electrically without use of boiler compound, feedwater treatments, water softeners or similar agents. No necessity to analyze boiler feedwater. Anodes connected to positive pole or electrical energy source are immersed in water, each set being controlled by separate set of balanced resistance units for regulating current. Rotary transformer or small motor-generator provides d.c. at about 10 volts and 10 amps. Boiler shell and tube serve as negative pole or in case of condensers, through insulated studs in the door to anodes. Anodes always positive, boilers negative. Anodes gradually destroyed, and protective hydrogen film built up on interior surfaces of unit.

*Niagara Combustion Corp., Niagara Falls, N. Y.*

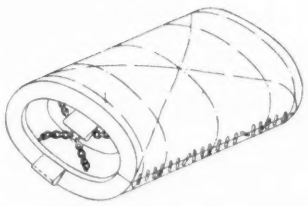
## INDUSTRIAL ANALYZER

MODEL 639 is self-contained test equipment designed to analyze industrial loads by measuring current, voltage and power in single and polyphase circuits, as well as power factor in three-phase circuits. Detects overloaded or un-



derloaded motors. Combines in oak carrying case four Weston Model 610 instruments: voltmeter, wattmeter, power factor meter and ammeter, latter with an adjustable pointer stop which allows maximum value of starting current to be quickly determined. Circular A-500A.

*Weston Electrical Instrument Corp., Newark, N. J.*



## JOURNAL LUBRICATOR

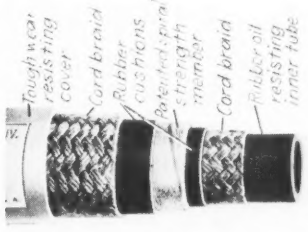
"STAPAX" lubricator in standard sizes for standard journals and custom-made for special sizes. Of fine quality felt controlled by "spider" that holds it in place mechanically.

*Lubrication Products Co., 1531 W. 25th St., Cleveland, Ohio.*

## COMPENSATED AIR HOSE

COMBINES advantages of both wrapped duck and braided hose. Two strength members, braided cord for longitudinal stresses and spiralled strength member for expansion and lateral stresses, both welded in rubber. Avoids internal friction and chafing and resists surge and pulsation.

*Manhattan Rubber Mfg. Division, Raybestos-Manhattan, Inc., Passaic, N. J.*



## LANCE-TYPE PYROMETERS

PORTABLE or lance-type low-priced pyrometer is available in three different temperature ranges, 800, 600 and 2,500 deg. F. Units are low-resistance type, combining high accuracy with rugged construction. Protecting case and handle single aluminum casting. Used in determining heat losses due to defective or broken baffles, loose brick, excess air, soot, scale, warped doors or leaky settings. Called "Hold-Heet," and special bulletin available.

*Russell Electric Co., 363 West Huron St., Chicago, Ill.*

## RUBBER SUBSTITUTE

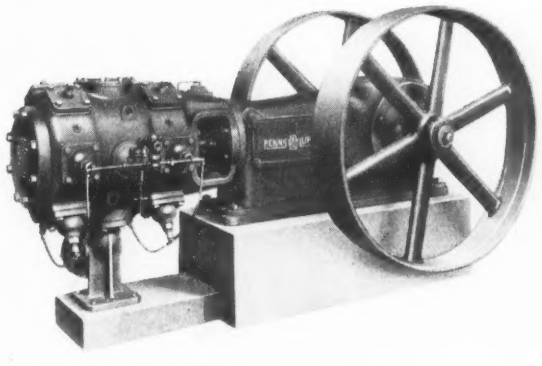
"KORASEAL" may be varied by compounding from hard to soft doughy consistency, and can be molded into any shape, is odorless, and made in a variety of colors. Resists swelling when exposed to oil and greases, and disintegration in presence of corrosive chemicals. Provides tight seal when used as piston packing.

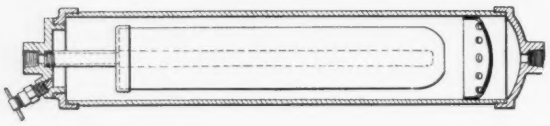
*Mechanical Division, B. F. Goodrich Co., Akron, Ohio.*

## HORIZONTAL SINGLE-STAGE COMPRESSORS

TYPE T, horizontal, single-stage compressors have roller bearings, completely inclosed frames, bored and ground crosshead guides, solid crossheads, fork-end wedge-adjustable connecting rod, double counterweighted crankshaft, large air passages, and water-jacketed cylinder and heads. Either belt or direct-connected drive for permanent or semi-permanent installation, and for compressing air or commercial gases. Uses company's "Simplate" valve. Cylinder sizes from 6 x 7 to 20 x 13 in., speeds from 400 down to 275 r.p.m., giving piston displacements 89 to 1,293 c.f.m.

*Chicago Pneumatic Tool Co., 6 East 44th St., New York, N. Y.*

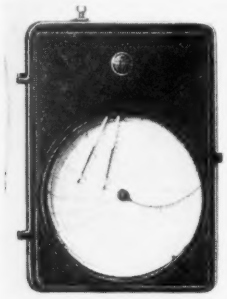




### AIR FILTER

FILTER element is a hollow candle of diatomaceous earth. Positive air purification. Two sizes, 8 and 16 c.f.m., in either case with ¼-in. pipe connection. Larger size illustrated is 16 in. long by 3½ in. outside diameter. Candle walls in 16-cu.ft. filter are ¾-in. thick and, as air is forced through wall, there is from 5 to 7 lb. pressure drop. Porosity can be controlled as required. Maintenance expense low, because candle is simply taken out of shell and outer surface sanded off when it becomes coated. Candle is placed in shell with outer end on stem raised about 3 in. Air is forced from outside of candle to center, while water, oil and pipe scale are shunted off to drop to bottom of shell, where petcock is provided for draining. Case chromium plated. Free test.

*Clean Air Filter Co., 1440 Broadway, New York, N. Y.*



### METER CASE

TYPE W case is now standard for this company's line of meters. Cast aluminum alloy. Sponge rubber gaskets make door moisture and dust-proof. Chart dial sized so that pressure spring stuffing box and other working parts are visible when door is open. For flush mounting, flange is casted integral with case with door hinged to flange. In flow control instruments, air supply gage and gage indicating pressure on diaphragm head of control valve are mounted on brackets inside, and door has two additional round windows. All other connections are behind panel board. Black finish.

*American Meter Co., 60 East 42d St., New York, N. Y.*

### SMALL CIRCUIT BREAKER

ITELITE in capacities suitable for protection of commercial wire sizes from 15 to 600 amp., and voltages up to 250 d.c. and 600 a.c. Includes single, double and 3-pole in various cases. Breakers trip-free of handle, can be operated in any position, and have quick make-and-break toggle action. Hot-molded Bakelite case and cover. Bi-metallic thermal element, deionizing arc quencher. Bulletin 634.

*I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia, Pa.*

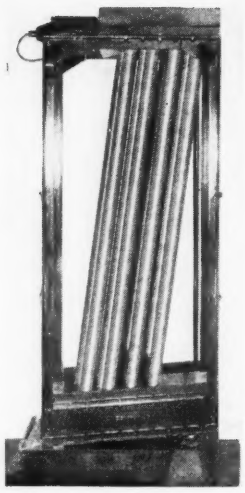
### DUST CATCHER *(Photo right)*

"DEDUSTER" is of water-film type, consisting essentially of nests of elements with tubes having outer surfaces corrugated to form spiral thread. Above these is water reservoir feeding water to elements, suitable feedwater control valves, cleaning means, dampers, hoppers, and proper structural steel work. All parts which flue gases and water contact are corrosion-resisting material. Water requirements are ½ lb. per min. per element. Maximum drop in flue-gas temperature will not exceed 150 deg. F., or 0.6 in. water pressure drop at normal velocity. Unit is small and light in weight for capacity. Water film so thin and construction such that even at high velocities flue gases will not carry water particles into chimney. Spiral thread arrangement keeps 100 per cent wetted surface by forcing water particles to follow spiral path. This also gives twice surface area of plain tube same diameter.

*Diamond Power Specialty Corp., Detroit, Mich.*

### INCLOSED HORIZONTAL-DUPLEX PUMP

SELF-contained power end supported on foundation through its length. 18-in. stroke, totally-inclosed horizontal-duplex power



pump, built for continuous duty. Frames cast enbloc moving parts totally inclosed. Crankshaft, pinion and crankpin bearings self-contained, tapered rollers, all flood lubricated. Gear and pinion pressure sprayed. Main gear and pinion full herringbone of any ratio required up to 9.66-1. Either packed piston or outside end-packed plunger type liquid end for hot or cold liquids.

*Worthington Pump & Machinery Corp., Harrison, N. J.*

### ROTATING SHAFT PACKING

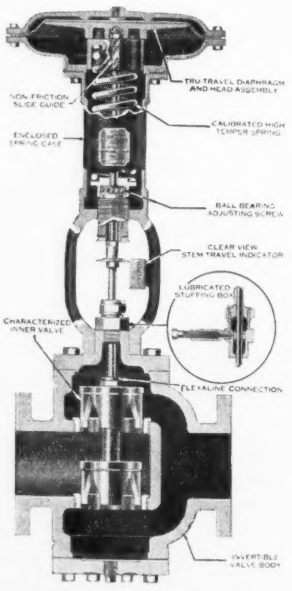
"DURASEAL" seals pumps, exhausters, etc., working gritty and/or corrosive liquids and gases. Can be applied to ordinary stuffing boxes. On moderate pressures outside assembly (as illustrated) is used. In this a bushing is placed in stuffing box, in which it remains stationary. Flexible metallic or other suitable packing is applied in grooves or bushings to prevent leakage along stuffing-box wall. Actual packing or rotating member is outside stuffing box, and consists of a collar set on shaft, ahead of which, toward stuffing box, is a compression chamber in which flexible packing is provided to prevent leakage along shaft. Outside disk is a steel ring which rotates against bushing, steel ring and bushing faces being ground and lapped to make a perfect joint. Soft packing in compression chamber rotates with shaft, thus avoiding wear. On higher pressures, member which rotates with shaft is placed within stuffing box and revolves against a special stationary bushing. Variety of metals and other materials may be used to suit particular corrosion conditions.

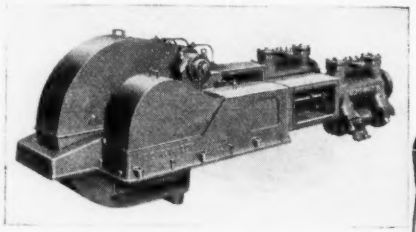
*Durametallic Corp., 2108 Factory St., Kalamazoo, Mich.*

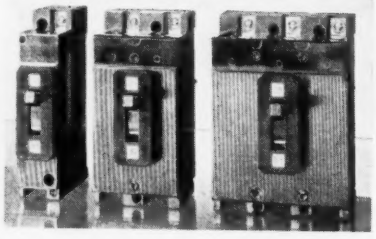
### CONTROL VALVES

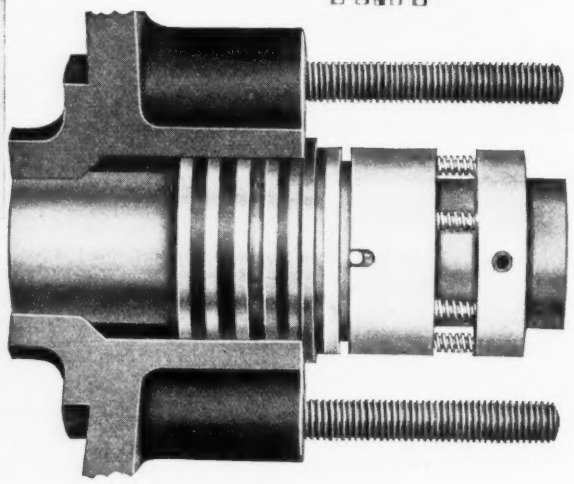
TYPE 57T Tru-Travel diaphragm control valve for pilot operation has special design head, long-travel diaphragm and non-friction slide guide. Ball-bearing adjusting screw for easy changing of settings. High-tempered calibrated adjusting spring. Special "characterized" inner valve, or bevel-seated or plain V-notch types, depending on throttling ability required. Special valve-stem connection avoids binding of inner valve.

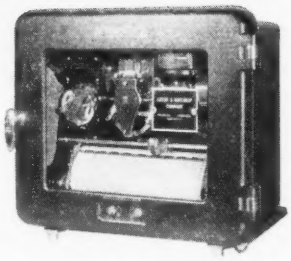
*Fisher Governor Co., Marshalltown, Iowa.*





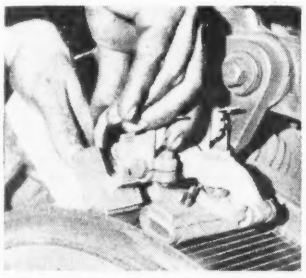




## MULTI-COLOR RECORDER

SPECIAL marking system for Micromax strip-chart recorders of two, three, four or six points, permits numerals in colors. With each thermocouple, resistance thermometer bulb or other primary elements identified on chart by a numeral, and each numeral distinguished from others by color, reading of records is made easy and errors avoided. Colors used for printing are black, green, red, violet, yellow and blue. Print wheel has separate inking pad for each point recorded. Circular No. 314-1 shows actual chart.

*Leeds & Northrup Co., 4910 Stenton Ave., Philadelphia, Pa.*



## BRUSH SEATER

FOR seating carbon, graphite or metal composition brushes, this soft, slightly abrasive insulating material of fine texture saves more than 75 per cent of time of breaking-in brushes. Each brush is under operating conditions without shutting down machines, and avoids sparking due to poor brush contact. Does not scratch commutator, but does polish it. In use, seater is held at heel of brush, while brush is pressed down. Friction from commutator or ring releases brush-seater material which is carried under brush and picked up on pad on opposite side. Standard size $4\frac{3}{4}$ in. long x $1\frac{1}{8}$ in. wide x $\frac{5}{8}$-in.

*Ideal Commutator Dresser Co., 1005 Park Ave., Sycamore, Ill.*

## SCOOP TRUCK

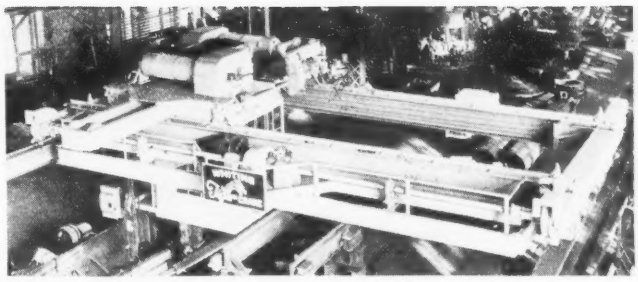
TYPE HFG (2,500-lb. capacity) will handle cinder or load coal into stoker hoppers. Lip of bucket lies parallel to or on ground and is pushed into pile by truck travel. Lifting mechanism then tilts bucket back and raises it to required height. In dumping, carriage is raised to top of uprights, where it is automatically latched and bucket allowed to go forward and dump. Carriage travel limit protected by switches. Parts interchangeable with those of other trucks. Bucket $\frac{1}{4}$-in. steel plate, arc-welded, with chrome-manganese wearing plate on lip. Cubic capacity and bucket shape variable to meet requirements. Either storage battery or gasoline electric power.

*Baker Industrial Truck Division, Baker-Raulang Co., Cleveland, Ohio.*

## THERMOSTATIC STEAM TRAP

No. 9-200, for steady or fluctuating pressures from 0 to 200 lb., is expressly designed for draining high-pressure steam coils, as well as removing condensate. No adjustment for change of steam pressure. Thermostatic bellows is helically corrugated tubing with heavy wall. Special top and bottom caps have internal screw threads of same pitch and profile as tubing, which is screwed into caps, then sealed with high-temperature solder. Shield protects element against abrasive action of steam and permits it to be removed from trap body while hot, if desired. Body and cap cast bronze. No gasket. Valve head and seat stainless steel, renewable. Three sizes, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in., with capacities 900 to 3,300 lb. of water per hr. at 200 lb.

*Sarco Co., Inc., 183 Madison Ave., New York, N. Y.*



## NOISELESS ELECTRIC CRANE

HERRINGBONE gears running in oil, forced lubrication on hoisting train and mechanical brake, Hyatt roller bearings throughout, accurately machined gears, all aid silent operation of "Tiger" crane. Construction makes for low maintenance, low power consumption, increased safety.

*Whiting Corp., Harvey, Ill.*

## PLUG FUSES

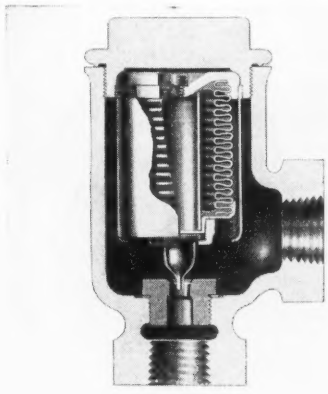
"BLAC-LINK" plug fuses have black link and white interior to make detection of blown fuses easier.

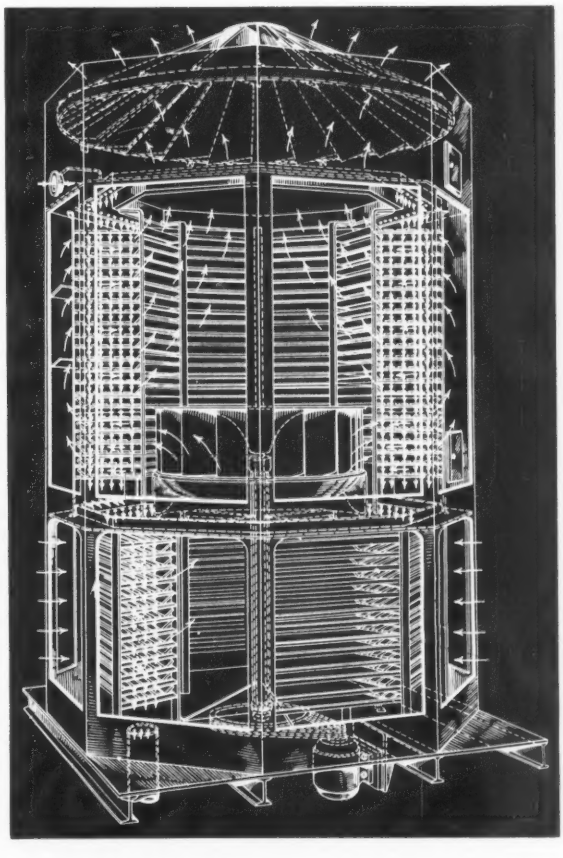
*Chase-Shawmut Co., Newburyport, Mass.*

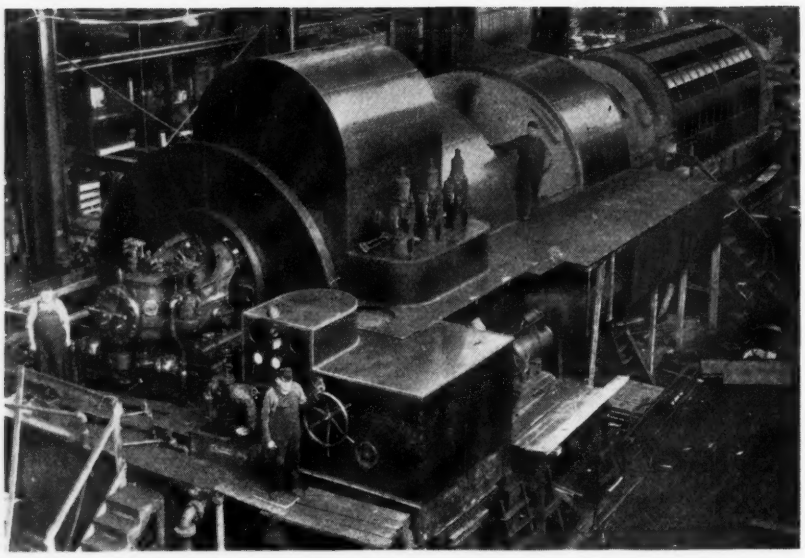
## MULTI-STAGE COOLING TOWER

COEY tower operates efficiently over wide temperature range, thus increasing capacity for given size and weight. Also reduces spray loss by special spray eliminator at top. In drawing, light arrows represent air flow, heavy arrows water flow. Water to be cooled is distributed by an overflow weir over top trough, from which it trickles down over a series of cypress baffles. Air entering at bottom passes through water three times before being exhausted at top. This gives thorough, uniform contact and reduces water consumption. Counter-flow arrangement. Tower shell heavy-gage copper-bearing steel. Air handled by centrifugal fan carried on ball bearings. This type fan delivers constant volume over wide range of static pressure, operates at low speeds, is almost noiseless, and avoid trouble from loose or broken blades. Placed inside tower in warm air path to avoid ice formation in cold weather. Driving motor in rain-proof inclosure. Smaller sizes direct-connected, larger sizes mounted on take-up and driven by V-belt. Can be used for steam or gas refrigeration. Built to capacity or in cell groups. Catalog 255.

*Research Corp., 405 Lexington Ave., New York, N .Y.*







**135,000 Kw. for Port Washington**

Rated at 80,000 kw., this 860-ton, 1,200-lb. pressure, 825-deg. temperature turbine-generator is soon to be delivered to Milwaukee Electric Railway & Light Co. Speed will be 1,800 r.p.m. Here it is shown assembled at Allis-Chalmers.

# POWER LINES

## Power Survey Submits First Report

Thomas R. Tate, director of the National Power Survey, Federal Power Commission, has given the following data on the survey in a special statement to *Power*. The National Power Survey was organized early in 1934 in response to an executive order issued by President Roosevelt. Instructing the Federal Power Commission "to make a survey of water resources of the United States as they relate to the conservation, development, control and utilization of water power of the relation of water power to other industries and to interstate and foreign commerce, and of the transmission of electrical energy in the United States and its distribution to consumers and on the basis of this survey" to "formulate a program of public works."

The survey was logically subdivided into two principal phases, the first covering investigation of power resources and the second of power requirements. Consequently the survey includes data on all types of power generation and transmission facilities, together with a study of the most efficient and economical utilization of the facilities. Compilation, interpretation of the data will not be completed until the end of the present fiscal year, but a preliminary report is being issued Feb. 8 by the Federal Power Commission.

The National Power Survey has had at work for months in the industrial power section, a group of engineers and experts on industrial uses of power and electrochemical and electrometallurgical applications. This division is studying the existing total power requirements of the 153,000 manufacturing establishments, mines and quarries. It is also studying increases in the use of power since the depression and the possibility of more complete electrification of existing industries.

The preliminary report will present a picture of the importance of the relationship between industrial power load and total load of the country, status of industrial activity from the power consuming standpoint present power supply tendencies and some new uses of power.

The final report will contain results of the comprehensive study of the present power requirements including use of power in industry, status of electrification of industry, amount of energy generated by industries themselves, amount purchased, maps and charts showing distribution of industrial loads, relations between generated and purchased power of private plants, industrial power costs, purchased power contracts, growth of power in industry, process steam requirements, interconnection of industry and public utilities, and electricity in the electrochemical-electrometallurgical processes, and the estimated future of all these sub-divisions. Data will also be included on the cost of distribution and utilization by different classes of consumers.

## API-ASME Unfired Vessel Code

A joint committee on unfired pressure vessels appointed some time ago by the American Petroleum Institute and the American Society of Mechanical Engineers has now completed the first edition of the API-ASME Code for Unfired Pressure Vessels for petroleum liquids and gases. It can be obtained from the A.S.M.E. at 29 West 39th St., New York, N. Y., and covers design, construction and repair of unfired pressure vessels for petroleum liquids and gases for metal temperatures not over 1,000 deg. F. and for gage pressures above 15 lb. per sq.in. It has design and construction data on fusion-welded, riveted and seamless forged vessels, inspection, repair and allowable working pressures, materials and other specifications. Questions and suggestions regarding the new code should be referred to the joint committee, whose secretary is R. P. Anderson, 50 West 50th St., New York, N. Y.

## T.A.P.P.I. Engineers To Meet in New York

The important part of engineering in industry will be emphasized at the annual meeting of the Technical Association of the Pulp & Paper Industry at the Waldorf-Astoria Hotel, New York, Feb. 18-21. A symposium of power plant operations will be held under auspices of the Heat & Power Committee including the following papers:

"Operating Practice in Switching and Power Distribution in Paper Mills," "Heat Storage and Recovery in Pulp and Paper Mills," "Practical Limitations in the Use of High-Pressure Steam in Turbines of 1,000 to 10,000 kw.," "Construction Problems Associated with High-Pressure Boilers for the Pulp & Paper Industry," "Practical Limits in Steam Temperature and Pressure in Paper-Mill Power Plants." The annual report on production and transmission of heat and power has been prepared this year by F. P. Wilmer, chief engineer of Albemarle Paper Co., Richmond, Va.

## Symposium on Paint

A symposium on paint and paint materials will feature the 1935 regional meeting of the American Society for Testing Materials to be held in Philadelphia, March 6. Two sessions with 14 papers will be devoted to this symposium.

## A.S.M.E. and A.S.C.E. Hold Joint Power Session

As part of the American Society of Civil Engineers Annual Convention, Jan. 16-19, in the Engineering Societies Bldg., New York, N. Y., two joint meetings were held with the Metropolitan Section, A.S.M.E. At one meeting three papers were presented on water measurements. Lt. F. H. Falkner, director, U. S. Waterways Experimental Station, Vicksburg, Miss., in "Bentzel Velocity Tube" described this device and the work done with it at the experimental station. This device consists of a long narrow U-tube with its ends pointing in opposite directions. In the downstream leg there is a tapered section in which is placed a float having a slight buoyancy and made from a piece of capillary glass tubing. When the tube is to be used it is filled with water, and the float goes to the top of the tapered section. When the ends of the tube are placed in a water current, there is a slight flow through the tube and the float moves down in the tapered section until its buoyancy balances the downward im-

pact of the water. It is found that this instrument can be calibrated very closely by towing through still water and is particularly useful for measuring velocities from 0.1 to 3 ft. per sec.

Two other papers, "Comparative Measurements by Venturi Meter and a 10-ft. Weir" by Charles M. Allen, and "Pitot Tube Practice" by Edward S. Cole, were the center of considerable discussion. It was evident that there is quite a divergence of opinion as to errors in these devices and to what extent these errors are influenced by waterway obstructions. Apparently in medium and large waterways these devices are more sensitive to pipeline and waterway conditions than is generally appreciated. This is probably not so true of flow in small pipelines and waterways and is one reason for disagreement in opinion of experimenters.

At the second session, three papers were presented on Tennessee Valley Authority projects. Barton M. Jones described engineering and design features of Norris Dam and power house, and W. M. Hall outlined engineering and design features of Wheeler Dam project. A paper, "Regulation of the Tennessee River," by James S. Bowman, was presented by L. F. Harza. At Norris Dam, two 66,000-hp. units will be installed to operate under a 200- to 130-ft. head and at Wheeler Dam one 45,000-hp. propeller turbine is being installed for a 54- to 43-ft. head. This plant is designed for 360,000 hp.

## O'Neill Heads Boston Smoke Work

Michael C. O'Neill has been appointed director of the Division of Smoke Inspection for Mass. Dept. of Public Utilities, 100 Nashua St., Boston. Mr. O'Neill, trained in steam engineering at Harvard and M.I.T., succeeds David A. Chapman, who left the post shortly after the work of the division was curtailed by legislative order as an economy measure. Activities of the division were restored in 1933 as a result of a widespread public demand.

## Big Turbines, Big Crowds at Allis-Chalmers Party

Thirty thousand people—employees with families and friends, outside industrial leaders, engineers—made "open house" Jan. 19 in the Allis-Chalmers plant in Milwaukee. "Miles of machines" on display, some of enormous size—for example five hydro and steam turbines aggregating 700,000 hp.

Chief power attractions were the first four turbines for the Boulder Dam power plant, which had been set up in the main erecting shop. Taking two years to build, these 150,000-b.hp. units are the most powerful turbines in the world.

The 80,000-kw. (1,230-lb., 825-deg.) tandem-compound steam turbine-generator for the new Port Washington station of Milwaukee Electric Railway & Light Co. was also on this floor and nearly ready for shipment. Another feature was a rotor of composite construction for the 125,000-kw. unit intended for State Line Station.

New departures in compressors and turboblowers included a two-stage rotary compressor, also an exceptionally compact turboblower, using a "gearmotor" to increase speed. The Brown-Boveri line of high-speed turbo-blowers was exemplified by a 50,000-cu.ft., 3,700-r.p.m. turbine-driven machine for Milwaukee Sewage Commission

## Welding Conference

The Fourth Annual Welding Conference of the Department of Industrial Engineering, Ohio State University, will be held Feb. 28 to March 1 in the Industrial Engineering Building, Columbus, Ohio. Program includes papers, demonstrations and exhibits.

## Navy to Continue Use of Stainless

Rumors of serious failures of corrosion-resistant steel in U. S. warships have raised some doubts as to the utility of these alloys in this service. The Navy has put a large tonnage of 18-8 strip and sheet into deckhouses, floors, hatch covers and other structures exposed to atmospheric corrosion in port and to dashing spray in a seaway. In these places the metal has served excellently, as well as it has in applications where the metal is submerged almost continuously.

But as a result of failures the Navy is abandoning the use of stainless steel in pipelines and tanks where sea-water more or less stagnant is constantly in contact with the metal. Under these circumstances, deep pits are corroded into it. Preliminary inspections have shown that the trouble is not the result of attack by chemical reaction with sea-water nor is it corrosion by oxidation, intergranular attack, or electrolysis. The trouble is apparently either "contact corrosion" under non-metallic substances (either scale or inclusions) or under solid particles brought in by the water, or corrosion by "oxygen concentration cells" existing in porosities and pits or caused by lodgment of organisms or even dead organic matter of reducing or deoxidizing nature.

In any case the difficulty is not with sea-water which is freely circulating and well aerated but with sea-water which is relatively stagnant.

## 1½ Years of PWA

In 18 months, the Public Works program has produced 642,329,759 man-hours of direct employment at a cost of $1,063,303,-024. This is the sum actually spent from allotments totaling $2,542,794,754 for federal and non-federal projects, out of the $3,700,000,000 appropriated in 1933-34.

Classified according to type, $279,800,541, or 29% of the total of $985,681,949 allotted to state, county and municipal projects, as of Jan. 1, will finance construction of 1,741 utility plants or distribution systems (water, sewage, electricity, gas), 22% goes for buildings.

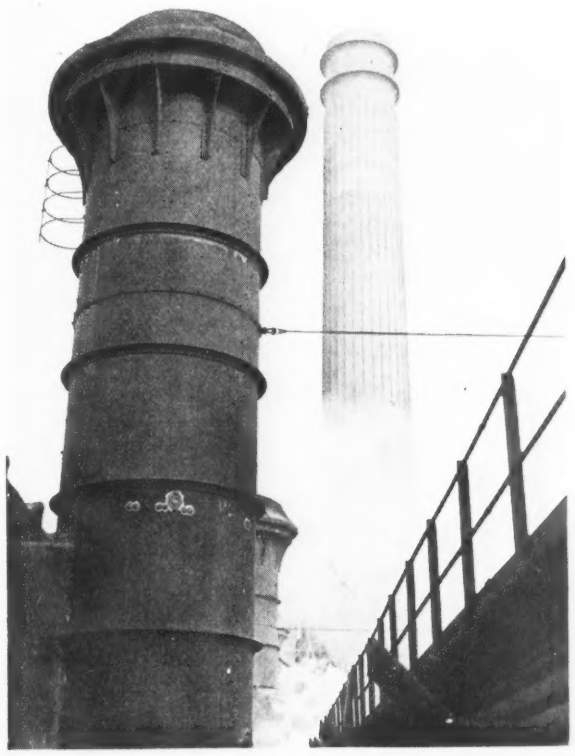
## M.A.P.I. Studies Obsolescence

Machinery and Allied Products Institute has recently inaugurated a survey of potential machinery requirements among its 900 members manufacturing machinery.

Approximately 95 per cent of responses already received assert that replacements will be made as soon as it is clear that business confidence and credit have been reestablished.

The organization is also enlisting other national trade organizations in the survey. Early returns indicate that replacements for five years have lain dormant. Until 1930 industry absorbed $8,000,000,000 worth of new machinery a year. Since 1930 the volume has declined to $2,000,000,000. Analysis of early responses discloses widespread variety in requirements, with machine tools, power plants and power transmission frequently mentioned.

JOHN KIRBY, formerly special assistant to Dr. Wilson Compton with the NRA, has joined the staff of Refrigerating Machinery Association with headquarters in Washington, D. C.



**Meet Deptford Dick**

Tenants of flats near London Power Co.'s Deptford Station complained of sulphur fumes, so 305-ft. "Deptford Dick" was built to replace eight stumpy chimneys like the one shown in the foreground Fox—Globe

## Diesels Stand Out At Motor Boat Show

Increasing interest in the diesel engine was indicated in the National 30th Annual National Motor Boat Show, Jan. 18-26 in New York. Most boats are now available with diesels. Included in new marine engines exhibited were two built by Winton for Ed Wynn's (The Fire Chief) boat "The Chief." Winton also exhibited its large V-type engines with steel frames.

Atlas Imperial Diesel Engine Co. exhibited a new 4-cycle, 4-cyl. solid-injection unit $4\frac{3}{4}$ x $6\frac{1}{2}$ in., rated 40 b.hp. at 1,000 r.p.m. Electric starter and generator are provided. Center frame and cylinder block are one-piece casting with removable liners. Full pressure lubrication is used and a new fuel-injection system, "Atimco," utilizes a distributor and fuel metering valve supplied by a constant-pressure accumulator. The same valve meters quantity of fuel to all cylinders.

Buda Co. exhibited a solid-injection, 6-cyl., 4-cycle high-speed, light-weight 4 x $5\frac{1}{2}$-in. diesel developing 65 hp. at 1,600 r.p.m. or 85 hp. at 2,000 r.p.m. (intermittent service). Cylinder block and crankcase are one piece, with liners. Special cylinder head has latest M.A.N. type combustion chambers with after-chamber. So-called "shock absorber" feature to assure smooth operation and remove smoke.

Bolinders Co. exhibited a light-weight engine, 33 lb. per b.hp. in three sizes, 1, 2 and 4 cyl., 25 hp. per cyl., $7\frac{1}{8}$ x $7\frac{1}{8}$ in. Normal speed 800 r.p.m., maximum 1,000 r.p.m. Cylinders are cast individually. The unit is a two-cycle, solid-injection design.

Cooper-Bessemer Corp. exhibited two of its smallest diesels, the smaller $5\frac{1}{2}$ x $7\frac{3}{4}$ in., with 3, 4, 6, or 8 cyl., rating 15 or 25 hp. per cyl. depending on speed. The larger has 8 x $10\frac{1}{2}$-in. power cylinders rated 25 to 40 hp. per cyl. depending on speed. The first type is started by storage battery and uses a Bosch injection system with a special combustion chamber. The larger engine, built as a 3-, 4-, 6- or 8-cyl. unit, has a modified common-rail injection system with a new atmospheric release principle to avoid nozzle trouble and objectionable noise. Injector valves are built in blocks of 3 or 4.

Fairbanks, Morse & Co. exhibited its two-cycle, opposed-piston unit described some time ago in *Power*, showing the 6-cyl., 5 x 6-in. model rated at 300 hp. This unit is built in several combinations of bore and stroke running at standard speed of 720 r.p.m., the larger units being of welded construction. In addition to the opposed-piston unit, the company exhibited five other diesels, one a 2-cycle design, the others 4-cycle.

National Superior Co. exhibited a light-weight high-speed diesel of the 4-cycle solid-injection type with 2, 4 or 6 cyl. and enbloc construction. Speed ranges from 300 to 2,000 r.p.m. and pistons and rods can be removed without disturbing cylinder heads or dismantling. The company also showed the medium-speed unit which is built in sizes from 65 to 350 hp.

Sterling Engine Co. again showed its crankless diesel. Hill Diesel Engine Co. showed a V-8, 200-hp., 5 x 7-in. unit, a 60-hp., 6-cyl. $3\frac{1}{2}$ x 6-in. engine (also in 4-cyl., 40-hp. size) and a 50-hp., 4-cyl., 5 x 7-in. unit. Cummins Engine Co. showed its HMR model, available in 4-cyl. or 6-cyl. sizes (100 and 55 hp.) $4\frac{7}{8}$ x 6 in., 1,500 r.p.m. (max. speed), Bronander Engrg. & Research Corp. showed its opposed-piston units, made in engine-generator units of 3-25 kw.

## No. 1 Park Ave. Costs Reported

According to a report in the New York *World-Telegram*, No. 1 Park Ave. has reduced its power bill from $45,007 a year to $26,012 by installing its own automatic diesel plant. Savings are expected to pay for the plant in about three more years, five years after installation, and the annual electric bill will then fall to $14,500, saving $30,500 a year. Cost of installation was $122,760, the installing company (Chicago Pneumatic Tool) contracting to maintain and operate the plant at a guaranteed cost of $14,500. Amortization of the investment in five years required $24,502 annually and interest averages $3,144.18 a year, a total of $42,796.18 a year. Cost for power was formerly $45,007 for 1,669,000 kw.-hr. The new plant is expected to turn out power for about a quarter of this amount or 8.7 mills per kw.-hr.

## Muskogee, Okla., Correction

On page 697 of December (1934) *Power* appeared the following erroneous statement: "Muskogee, Oklahoma, authorizes $1,125,000 in city bonds for a public light and power system."

The facts, as subsequently determined, are that the citizens of Muskogee, on Nov. 6, 1934, defeated a proposed bond issue to build a municipal light plant and to build or purchase from the Oklahoma Gas & Electric Co. the electric distribution system. The vote was 3,117 against the bonds, 1,024 for. All of the 31 precincts in the four wards in Muskogee returned a majority against the bonds.

## BUSINESS NOTES

Edge Moor Iron Co., Edge Moor, Del., has been appointed exclusive sales agents in all countries for pulverized-fuel equipment for boiler purposes by Whiting Corp., Harvey, Ill.

Belden Mfg. Co., 4689 West Van Buren St., Chicago, Ill., has opened a warehouse in the New Terminal Commerce Bldg., 401 N. Broad St., Philadelphia, with E. V. Blake as eastern manager.

G-E Air-Conditioning Institute will start a special air-conditioning school for power company men at the General Electric plant, Schenectady, N. Y., Feb. 11. This school, one week in duration, will follow the close of the sales engineering school for representatives of air-conditioning dealers. Enrollment is expected to reach 200.

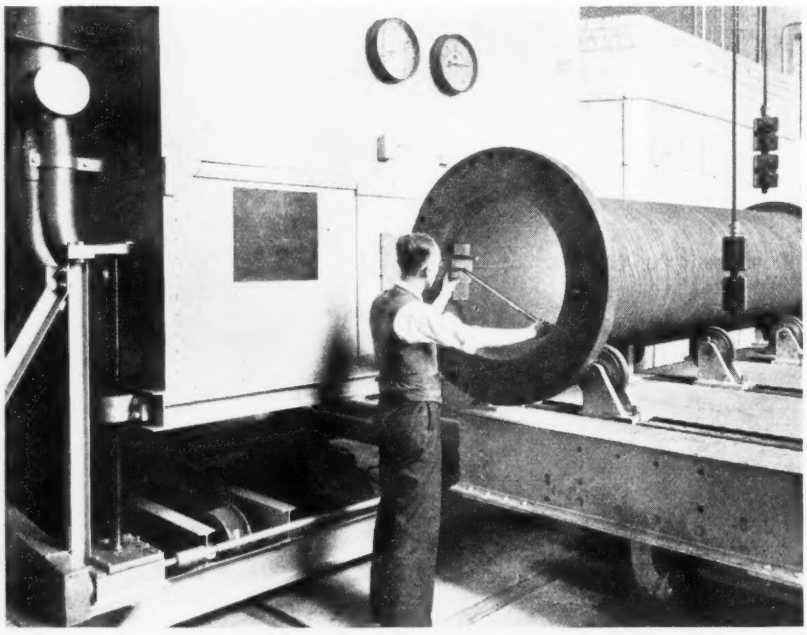
Hemphill Diesel Engineering Schools, with schools in Chicago, Los Angeles and Seattle, are establishing their largest school in New York with offices at 500 Fifth Ave.

R. E. Martin, 1027 Hunt Bldg., Tulsa, Okla., has been appointed exclusive sales agent for American District Steam Co., North Tonawanda, N. Y., for the State of Oklahoma.

Armstrong Cork Products Co. has been formed as a subsidiary of Armstrong Cork Co., and Armstrong Cork & Insulation Co. to distribute their products as of Jan. 1. Executive offices will be in Lancaster, Pa.

Sarco Co., Inc., New York, has opened a branch office at 1025 Broad St., Newark, N. J., with Walter Andrews and H. W. Angelery in charge.

A. Schrader's Son, Inc., has changed its name as of Jan. 1 to Scovill Mfg. Co., Inc., A. Schrader's Son Division, 470 Vanderbilt Ave., Brooklyn, N. Y.



**X-Ray Inspects Heat Exchanger Shells**

X-ray room at Westinghouse, showing the machine, control room and special battery-driven truck for carrying pieces to be inspected. The truck is controlled entirely by pushbutton. The cassette is set with a telescoping rod pointed at both ends. An enclosed spring holds it firmly in position. Focal gage, elevator gage and copper plate with index number all can be seen from the truck platform.

## PERSONALS

H. W. SWEATT, for the last eight years vice-president and general manager of Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., has been made president, to succeed M. C. Honeywell, who becomes chairman of the executive committee. Mr. Sweatt has been with the company for more than 20 years.

DR. J. C. HODGE, of Babcock & Wilcox, spoke on "Non-Destructive Testing of Welded Joints, its Development, Practice and Limitations" before a joint meeting of the Metropolitan Section, A.S.M.E., and the New York Section, American Welding Society, Jan. 14. Two other speakers, R. K. Hopkins of M. W. Kellogg Co., whose subject was "Physical Properties of Fusion Welded Joints as Produced by Manufacturers of Class I Pressure Vessels," and A. C. Weigel, of Combustion Engineering Co., Inc., whose subject was "Corrosion Resistance Tests of Welded Pressure Vessels," contributed to this symposium on recent developments in welded pressure-vessel construction.

L. H. MILLER, chief inspector of the city electrical department, Vancouver, B. C., has been recommended to the city council for appointment as city electrician to succeed C. H. Fletcher, who retired Dec. 31. He has been in Vancouver since 1911 and on the city staff since 1916.

CAPT. GEORGE M. ALEXANDER, president of the Monongahela West Penn Public Service Co., Fairmont, W. Va., resigned Dec. 15, and will be succeeded by A. C. Spurr of Pittsburgh, formerly assistant to the president of the West Penn System.

E. W. SECKENDORFF has become a member of the technical staff of Battelle Memorial Institute, Columbus, Ohio. He has been engaged since 1921 in extensive research on pulverized coal operations and electric power generating problems with Stone & Webster.

ALFRED GORMAN NEAL, vice-president and general manager of Potomac Electric Power Co., has been elected to the board, Potomac Electric Power Co. and Washington Railway & Electric Co. He succeeds to the membership made vacant by the death of the late Harley P. Wilson, and has been with the company since February, 1918.

VICTOR B. GERSHON, research engineer, Aquatic Chemical & Metallurgical Engineers, spoke on "Scientific and Practical Aspects of Corrosion and Scale in Boiler Plants and Other Water Systems" at the regular January meeting of the New York Chapter, A.S.H.V.E., Jan. 21. He described temporary and permanent hardness and showed the differences in method of treating them. Other speakers included W. H. Finkelday, consulting metallurgist and chemical engineer of Singmaster & Breyer, who discussed corrosion of metal, and Cecil M. Stern, consulting engineer of Metropolitan Refining Co., who gave results of a number of tests on use of various chemicals for preventing corrosion of air-conditioning apparatus.

LEONARD W. HORR, former Chicago manager of Henry Vogt Machine Co., Louisville, Ky., has joined the cooling equipment division of Binks Mfg. Co., 3114-40 Carroll Ave., Chicago.

WALTER H. GARDNER, manager of the special sales division, Caterpillar Tractor Co., Peoria, Ill., has been elected to the board of directors of Internal Combustion Engine Institute.

EDGAR J. KATES, consulting engineer and diesel engine specialist, has moved his office to 415 Lexington Ave., New York, N. Y.

RALPH H. CLORE has become general sales manager of the Medart Co., St. Louis, Mo. He was general sales manager of the U. S. Electrical Tool Co.

HOWARD COONLEY, president of Walworth Co., has been reelected president of the American Standards Association for 1935. Mr. Coonley, who represents the A.S.M.E., has served two terms as president.

R. M. SPURCK, formerly assistant manager of the switchgear engineering dept., General Electric Co., has been named manager of sales in the circuit breaker section, switchgear sales division. H. E. Starbuck, formerly manager of sales of the circuit breaker section, has been appointed general assistant of the switchgear sales division.

J. R. WHITEHEAD, manager of the Stoker and Research Division, Fairbanks, Morse & Co., Chicago, has been elected president of the Stoker Manufacturers Association, to succeed W. H. Rea, president, Detroit Stoker Co., Detroit, who has served since the last annual meeting in June, 1933.

S. V. TRAVIS has been appointed manager of the generator and converter division, central station dept., General Electric Co., to succeed G. F. Brown, who died late in November. He has been with the company since 1910.

ARTHUR D. DURGIN, for the last 15 years with International Engineering Works, has joined Bigelow Boiler Co., Kendall Square Bldg., Cambridge, Mass.

CARL STRIPE, for the past two years assistant to the vice-president, Davis Coal & Coke Co., has joined the sales organization of Combustion Engineering Co., Inc., 200 Madison Ave., New York. He will be in charge of industrial stoker sales under direction of H. S. Colby, general sales manager.

W. J. MCDONOUGH has been appointed sales manager of Northern Equipment Co., Erie, Pa. He has been with the company since 1922. Thomas A. Road has rejoined the engineering dept., which he left in 1933.

E. W. BIXBY, formerly sales manager for Columbian Iron Works, has joined the Memphis office of Pittsburgh Equitable Meter Co. and Merco Nordstrom Valve Co.

ARTHUR C. WILLARD, president of the University of Illinois, was one of the chief figures in the A.S.H.V.E. 41st Annual Convention in the Hotel Statler, Buffalo, Jan. 28-30. He is a past-president of the organization.

ALFRED KULLMAN, research engineer of Mechanical Power Engineering Association, addressed a group of Philadelphia engineers Jan. 10 on modern group drive and its applications.

## OBITUARIES

FREDERICK H. COOK, 75, for the past 50 years consulting engineer of Holyoke (Mass.) Water Power Co., died at his home Jan. 16.

ARTHUR STANLEY BENNETT, former chief inspector of boilers and machinery for the British Columbia Government, died recently in New Westminster, B. C. He was appointed inspector of boilers in 1910, and chief inspector in 1929, and retired in 1930.

JOHN GALLAGHER, 75, formerly operating engineer on the staff of the Boston *Daily Globe*, died suddenly at his home in Boston, Jan. 6.

PAUL HENSELER, 62, prominent steam engineer specializing in the marine field, died in South Somerset, Mass., Jan. 23. He was port engineer at Fall River for C. D. Mallory, Inc.

HERBERT TORREY, 76, chief engineer at the Hanover, Mass., mill of E. H. Clapp Rubber Co., and with the company for 61 years, died suddenly in Pembroke, Mass., Jan. 7.

WILLIAM W. SMITH, 62, for many years operating engineer in the Charleston power station of Boston & Maine Railroad, Boston, Mass., died suddenly Jan. 22.

GEORGE W. BOWERS, 74, former consulting mechanical engineer of Boston, who retired ten years ago, died suddenly at his home in East Somerville, Mass., Jan. 1.

JOHN S. ALMEIDA, chief engineer of the Majestic Bldg., Detroit, Mich., for 9½ years, died suddenly recently. Born in Spain, he spoke seven languages. He was highly respected and well liked by power engineers of the Detroit area.

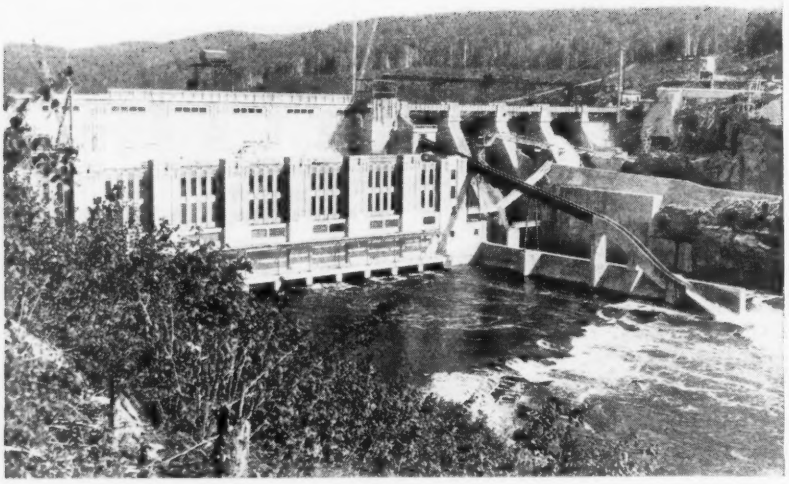
HARRY L. MITCHELL, 64, for the past 15 years chief engineer of the plant of Providence (R.I.) Dyeing, Bleaching & Calendering Co., died suddenly as he was about to leave work Jan. 28.

CHARLES FRANCIS DOOLEY, 77, for many years stationary engineer for Howard & Bullough Machine Co., Pawtucket, R. I., died there Jan. 24.

JOHN A. GINTY, 81, for many years a mechanical engineer associated with E. B. Badger & Co., Boston, Mass., died at his home in Boston Jan. 6.

WILLIAM WATTS MACON, 59, for 23 years with "The Iron Age," and during 14 years of that period its managing editor and editor-in-chief, died Jan. 1 in New York following a cerebral hemorrhage.

PROF. GEORGE LEONARD HOSMER, 60, for 37 years a member of the faculty at M.I.T. and a prominent consultant in water power projects, died at his home in Woburn, Mass., Jan. 10. He retired last fall.



**Rapide Blanc Goes into Operation**

**Only large hydro plant to go into operation in Canada in 1934, Rapide Blanc plant of Shawinigan Water & Power Co., on the upper St. Lawrence River, Quebec, has an initial capacity of 160,000 hp. in four 40,000-hp. units operating under 108-ft. head at 109.1 r.p.m. Ultimate capacity will be 240,000 hp. in six units.**

# STRAWS

## Pointing the way business winds blow

U. S. ENGINEER OFFICE, Customhouse, Portland, Ore., Maj. Charles F. Williams, district engineer, plans call for bids during the next six months for features of construction and equipment installation for Bonneville Navigation and Power Project on the Columbia River near Bonneville, Ore., covering in all 22 contracts, estimated to total $11,203,000. Principal awards will be (first noted date approximate time of advertising for bids and second, approximate time of closing bids):

Two main generating units and accessories, estimated cost $1,600,000; March 1-May 1.

Two main water turbines, estimated cost $1,580,000; call for bids made, closing Feb. 15.

Emergency dam and derricks for lock, estimated cost $154,000; call for bids made, closing about Feb. 15.

Main transformers, part of switchgear and accessories, $365,000; April 1-May 1.

Electrical distribution system for permanent buildings, streets, etc., $21,000; Feb. 1-March 1.

Power house, intake and draft tube gantry cranes, $122,000; May 15-June 15.

Power house, intake gates, $146,000; May 15-June 15.

Gate and valve machinery for lock, $61,000; May 10-June 15.

Lock gates, tainter valves and floating mooring hooks, $390,000; May 10-June 10.

Power house, stop logs for draft tubes, $100,000; May 15-June 15.

Lower approach canal to lock, $330,000; May 5-June 5.

Power house pumps, compressors, oil tanks, fire equipment (part), $47,000; April 15-May 15.

Power house machine shop equipment, $12,000; May 15-June 15.

Union Pacific railroad change below Cascade Rapids, $1,700,000; April 15-May 15.

Channel improvements through Gorge, $320,000; April 15-May 15.

Crest gates and gantry cranes for main dam, $1,190,000; May 15-June 15.

Other work includes land improvements below Cascade Rapids, new Evergreen Highway, Bradford Island and Washington shore improvements.

KENTON, OHIO, completing plans for municipal electric light and power plant, including electrical distribution system, for which financing for $556,000 is being arranged. Bids at early date. H. P. Jones, Second National Bank Bldg., Toledo, Ohio, consulting engineer.

BOARD OF DISTRICT COMMISSIONERS, District Bldg., Washington, D. C., is planning early call for bids for new sewage disposal plant, for which a fund of $8,000,000 is being secured through Federal aid, work to be divided into a number of contracts. Bids for initial contract, covering main pumping station and grit chamber, estimated to cost $500,000, with equipment, will be opened about March 15; preliminary sedimentation tank bids will be opened about April 1; those for main pumping plant equipment will be opened about May 15; for sludge digestion tanks and accessories, about May 15. On or about June 1 bids will close for central power plant and equipment, estimated to cost approximately $1,200,000. During period noted, from March to June, a number of bids also will be asked for minor features. Metcalf & Eddy, Statler Bldg., Boston, Mass., consulting engineers.

BUREAU OF RECLAMATION, Denver, Colo., will receive bids until Feb. 15 for two motor-driven vertical-shaft pumping units, with accessory equipment, for Melhase-Ryan sump drainage pumping station, Klamath Project, Oregon-California (Specification 660-D). Also, until Feb. 18, for two motor-driven vertical shaft pumping units, capacities of 13 sec.-ft. and 5½ sec.-ft., respectively, for North and South pumping plants, Advancement District of the Owyhee Project, Oregon-Idaho (Specification 661-D).

BOONE, IOWA, is considering early special election to vote bonds for $800,000 for a new municipal electric light and power plant, with transmission and distribution lines. Plans will be drawn soon.

MORRISVILLE, PA., has appointed a special committee of three Councilmen, Paul Nichols, Elwood Kohl and Russell Pfleger, to investigate and secure estimates of cost for a proposed municipal electric light and power plant, including information on equipment.

STEWART, B. C., is installing three 630-hp. 6-cyl. Fairbanks diesels, with auxiliaries in a new power plant to replace the one recently destroyed by fire.

CARRIER CORP., Newark, N. J., has received a $1,000,000 loan from the Federal Reserve Bank to be used to help this company develop its air-conditioning market.

CLAYTON, N. M., is preparing plans for an additional well and pumping equipment for municipal water supply, also for a modern closed cooling system for 600-hp. internal combustion engines at the municipal electric generating station and pumping plant. Equipment to be purchased includes 200-g.p.m. capacity cooling tower, heat exchangers, motor-driven circulating pumps for both raw and soft water, piping and valves, etc. (up to 6 in.), 5,000-gal. elevated tank, motor-driven turbine-type well pumps (approximately 80 g.p.m. for 120-ft. well). Plans are being prepared by and work will be under supervision of J. H. Bender, city manager, Clayton, N. M.

WESTINGHOUSE reported higher sales of air-conditioning units the first four working days of January than those obtained throughout December and January twelve months ago. Included among orders are units for air-conditioning a court house in Northern California, equipment for a citrus fruit processing plant in Southern California, dining room equipment for three hotels in a Mid-Western chain.

ASHLAND, VA., is conducting a survey with a view toward installing a diesel-electric municipal power plant. An installation similar to that at Culpeper, Va., is planned, with one main diesel unit and a small auxiliary.

LAMONI, Decatur Co., Iowa, has been given a PWA loan and grant of $97,000 for construction of a municipal power station to include two 300-hp. diesel-electric generating sets and auxiliaries and a distribution system.

TVA, Jan. 18, awarded contracts to the value of $1,303,305 for generating equipment for Norris and Wheeler Dams. Westinghouse will provide two 56,000-kva. generators, with auxiliary equipment, for Norris Dam, total cost being $878,520. Both units will be of impeller-type design, very compact. Total weight will be about 1,320 tons. Generator speed will be 112½ r.p.m. Delivery will start near the end of 1935. General Electric Co., Schenectady, N. Y., will install one 36,000-kva. generator at Wheeler Dam, to cost $424,785, and to be completed in 1936.

TORRENCE, Los Angeles Co., Calif., has been given a PWA loan and grant for the purchase of existing privately owned waterworks systems and installation of a well and pumping plant.

BOULDER DAM is now storing water, all tunnels but No. 4 (Arizona side) being closed Feb. 1. 3,000,000 acre-feet of water are expected to be stored by June 1, but 3 or 4 years will be required to fill the reservoir.

COLUMBUS, OHIO, has been given a $320,000 grant to aid in extension of existing municipal electric plant by construction of a power house and installation of a 10,000-kw. turbine-generator, a 12,500-sq.ft. boiler with auxiliaries and control equipment and coal, ash and circulating water systems.

NORTH BALTIMORE, Wood Co., Ohio, has been given a PWA loan and grant of $109,000 for construction of a water works system in competition with a private system.

FEDERAL GOVT. has allotted $3,780,000 for a power plant in New York. Present costs of steam and electricity purchased are $1,209,000 a year, of which the new plant would remove $700,000.

LE GRANGE, IND., has been given a loan and grant of $29,000 for improvements to the water works district, including three deep wells and pumping equipment.

MERIAM CO., 1955 W. 112th St., Cleveland, Ohio, reports sales of a 150-hp. gas engine to Callahan Coal Co., Salem, Ohio; a 150-hp. engine to Pleasant Valley Coal Co., Massillon, Ohio; 90-hp. unit to Frazer Ice Co., Galveston, Tex.; 90-hp. unit to Liebmann Ice Co., Pampa, Tex.; and a 50-hp. unit each to the Bison and Criterion Theaters, Shawnee, Okla. All these units were repurchased equipment, rebuilt by J. B. Meriam, the original designer.

GENERAL AMERICAN TRANSPORTATION SYSTEM, INC., 230 South Clark St., Chicago, Ill., an interest of the General American Tank Car Corp., same address, plans construction of a power house and large pumping plant in connection with new bulk-oil terminal on Houston ship channel, Houston, Tex., where tract of about 50 acres of land has been acquired.

SEWARD, ALASKA, has plans under way for a new municipal electric light and power plant, and proposes to begin work this spring. $125,000 through Federal aid.

WISCONSIN STEAM CORP., 335 McKinley Ave., Eau Claire, Wis., Sidney P. Hall, vice-president and general manager, is completing final plans and will begin work early in the spring on a new 1-story power plant on Dewey St., for central steam heating service. Project will include installation of steel pipeline for distribution, and is estimated to cost about $200,000.

FALLBROOK (CALIF.) IRRIGATION DISTRICT has plans maturing for new irrigation project using water from San Luis Rey River, estimated to cost close to $1,100,000. Bond issue at early date, with later financing through Federal aid. Project will include 1,600-hp. electric power plant using diesel engine-generating units, for service to a series of pumping plants. A number of booster pumping stations will be located along the river, while the generating plant will be built near Bonsall. Willis S. Jones, Claremont, Calif., consulting engineer.

HUNTINGTON, IND., is planning extensions and improvements in municipal electric light and power plant, with additional generating and accessory equipment. Additions will also be made in electrical distribution lines. Mayor C. W. H. Bangs is active in project.

PREMIER BREWING CO., High Point, N. C., J. Berg Von Linde, president and general manager, recently organized with capital of about $400,000, plans construction of a power house in connection with new brewing plant on tract of about 15 acres of land on highway between High Point and Greensboro, N. C., lately acquired. Brewery will consist of several units, equipped for initial capacity of about 50,000 barrels per year, and will cost over $150,000. Work scheduled to begin soon. Grattan Fox, president, High Point Paper Box Co., High Point, is interested in new company.

PLATTE VALLEY PUBLIC POWER & IRRIGATION DISTRICT, North Platte, Neb., Donald D. Price, chief engineer and business manager, is arranging plans for proposed transmission and distribution system in conjunction with hydro-electric power and irrigation project now under way. It is planned to build main transmission lines from generating station, near Sutherland, Neb., to North Platte, Grand Island, Lincoln, Omaha, Sioux City, Columbus and neighboring points, operating at 110,000 volts. The proposed system is estimated to cost about $1,500,000 additional, compared with original estimates and PWA appropriation, and financing for this sum is now in progress through Federal aid. With the more extensive transmission system, it is proposed to increase initial capacity of the main hydro-electric generating plant. Parsons, Clapp, Brinckerhoff & Douglas, 142 Maiden Lane, New York, N. Y., consulting engineers.

TWO OHIO MUNICIPALITIES, Niles and Harrison, are having surveys and estimates of cost made for proposed municipal electric light and power plants by Burns & McDonnell Engineering Co., 107 West Linwood Blvd., Kansas City, Mo. Harrison also contemplates installation of distribution system. Projects scheduled to mature soon.

KLAUER MFG. CO., Ninth St., Dubuque, Iowa, plans diesel plant for local sheet-metal stamping plant, estimated to cost about $40,000, with equipment. Surveys in progress.

STATE TEACHERS' COLLEGE, Morehead, Ky., is planning construction of new electric light and power plant. Bids at early date. Estimated cost over $75,000, with equipment. Financing has been arranged through Federal aid.

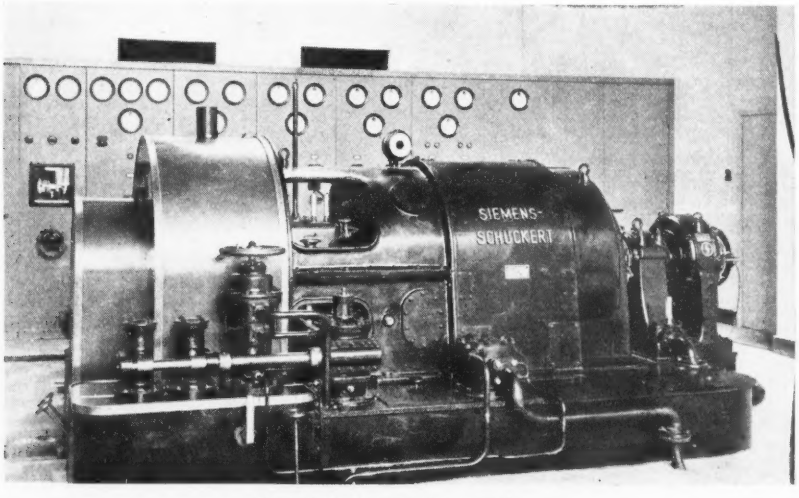
WOODBINE, N. J., is arranging early special election to approve plans and financing for a new municipal electric light and power plant, with distribution system. Estimates of cost are being made. Mayor Nathaniel Rosenfeld is active in project.

HARRISON, ARK., has plans nearing completion for new municipal electric light and power plnat, estimated to cost $130,000, with distribution lines. Special election being arranged to approve bonds, with call for bids to follow shortly.

U. S. ENGINEER OFFICE, Kansas City, Mo., Missouri River Division, plans an appropriation of about $20,000,000 for construction work on Fort Peck, Mont., power dam and hydro-electric power plant project, during fiscal year June 30, 1935, to June 30, 1936. Up to the first date noted, an allotment of $25,000,000 has been available. During next year, work will include dredging operations for dam construction, estimated to cost $5,875,000; diversion tunnels, spillways and gates, and other work incidental to dam and power plant installation. Power-plant construction is estimated to cost about $1,000,000. Maj. T. B. Larkin, district engineer, Fort Peck District, Fort Peck, Mont., in charge.

DECATUR, ALA., has engaged Francis & Haley, Brown-Marx Bldg., Birmingham, Ala., to prepare plans for municipal power station and electrical distribution system. Bids in near future. Appropriation of $350,000 secured through Federal aid.

STEEL & TUBES, INC., 224 East 131st St., Cleveland, Ohio, is planning a 40,000-sq.ft. addition. This will be a single-story modern factory type, costing about $125,000, and will be used by the company in producing electrically welded steel tubing.




**One-Cylinder Radial Turbine**

Compactness, short shaft, no gearing, good efficiency, simplicity are characteristics of this type of unit. This is a 750-kw. Siemens-Schuckert unit in which the turbine rotor is carried on an extension to the generator shaft. Steam flows radially through alternate concentric rings of stationary and moving blades.

## NEW BULLETINS

**Draft Gages**—Hays Corp., P.O. Box 299, Michigan City, Ind. "Bulletin 2018," Hays "Draftrol" Electric Contact Gages for Indicating and Controlling Draft, Pressure and "Differential Draft or Pressure."

**Diesel Fuel**—Two bulletins of Caterpillar Tractor Co., Peoria, Ill., "Fuels for the Caterpillar Diesel," and Issue No. 100 of "The Dotted Line," titled "What Oil Companies Say About Diesel Fuels."

**Boiler Water Level Indicators**—Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. Supplement WG-1804 gives further information on Yarway Eye-Line Indicator (mentioned on last page of Catalog WG-1803) particularly useful for high boilers.

**Expansion Loops** — Tube-Turns, Inc., Herald-Post Bldg., Louisville, Ky. Quick reference chart for designing expansion loops, using Tube-Turns and straight lengths of pipe or tubing. Wide range of temperature and pressure applications.

**Coal and Oil-Handling Equipment**—C. O. Bartlett & Snow Co., 6200 Harvard Ave., Cleveland, Ohio. 48-page Bulletin 73 gives layout drawings for coal- and ash-handling equipment to meet requirements of almost any industrial plant.

**Steel Floor Grids** — Hendrick Mfg. Co., Carbondale, Pa. 20-page booklet, "Mitco Products," describes open steel floorings, special treads and Armorgrids, particularly for power-plant use.

**Industrial Cable**—General Electric Co., Schenectady, N. Y. 128-page large-size catalog GEA-1838, "Industrial Cable," is a companion to Bulletin GEA-1837, and 80-page publication on how to select insulated cable. GEA-1838 describes and lists all standard types of insulated wire and cable for transmission, distribution and control, except paper-insulated types.

**Blowers** — Roots-Connersville Blower Corp., Connersville, Ind. 8-page Bulletin 22:23-B10 illustrates and describes standard and heavy-duty type blowers, discussing inherent characteristics and operating principles of rotary positive type, giving typical installations, sectionalized views, diagrams of driving arrangements and impeller design suitable for 10 lb. gage in single stage and up to 20 lb. compound arrangement.

**Arc Welders**—Lincoln Electric Co., Colt Road and Kirby Ave., Cleveland, Ohio. Welder Specification Bulletin No. 302, general classifications for d.c. motor-driven, Types SA300, SA400, SA600 portable welders. Two pages.

**Deaerating Heaters** — Cochrane Corp., 17th St. below Allegheny Ave., Philadelphia, Pa. Bulletin No. 700 discusses deaeration principles and equipment to protect piping, economizers and boilers, and to give greater flexibility.

**Separators** — Westfalia Separator Co., Inc., Bloomfield, N. J. Series of five new catalogs covering complete line of separators for both industrial and dairy fields. Two colors, with covers made like file folders.

**Steel Applications**—Republic Steel Corp., Massillon, Ohio. 12-page rotogravure tabloid showing exhibits at Century of Progress Exposition in which Republic products were used.

**Boiler Scale Control**—D. W. Haering & Co., Inc., 3408 West Monroe St., Chicago, Ill. New bi-monthly house organ, "H-O-H News," devoted to presentation of news and personnel items in scale and corrosion control and proportioning fields.

**Ventilating Equipment**—ILG Electric Ventilating Co., 2850 North Crawford Ave., Chicago, Ill. Booklet C50 is new condensed catalog and handbook of ventilating, heating, cooling and air-conditioning equipment. Made pocket size. 34 pages.

**Brewery Equipment**—Worthington Pump & Machinery Corp., Worthington Ave., Harrison, N. J. 12-page bulletin WP-1069, "Worthington Equipment for Breweries," includes data on equipment for manufacture, refrigeration, power plant and water supply.

**Heating Specialties**—The Bishop & Babcock Sales Co., 4901 Hamilton Ave., N.E., Cleveland, Ohio. 38-page Bulletin No. 10A, "Heating Specialties," shows vacuum and vapor low-pressure heating specialties, system of automatic temperature control, squirrel-cage fans, air washers and unit heaters.

# NEW PLANT CONSTRUCTION

***McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service***

**Ala., Florence**—Municipality plans municipal electric power plant. To exceed $30,000.

**Ala., Tuscumbia** — Municipality plans electric power plant. To exceed $30,000.

**Ark., Harrison**—City plans election to vote on bond issue for electric plant, oil engine equipment, $150,000. A. C. Moore, P. O. Box 305, Joplin, Mo., engr.

**Ark., Pine Bluff**—Arkansas Power & Light Co., Pine Bluff, plans constructing 2,200 mi. distribution line to provide electricity for farm communities. $3,000,000, depending on ability to obtain loan from Federal Govt.

**Ill., Galesburg**—City plans furnishing diesel power and generating equipment for municipal power plant. $75,000-$100,000. Now propose use of old waterworks building for housing, or may build new building. Engineer not appointed.

**Ind., Fort Wayne**—City Light & Power Co. making plans light and power plant addition. $31,600. C. McAnless, city engr.

**Ia., Boone**—Petition filed asking Council to call election on proposal to construct steam-powered municipal light and power plant and distribution system. $800,000.

**Ia., Lamoni**—Bids Feb. 18 (extended date), by City Council, general contract power house building and equipment, incl. cooling tower, oil tanks, 2 diesel engines and generators, auxiliary equipment and piping, station wiring, switchboard and complete distribution system. $100,000. P.W.A. project. Young & Stanley, Inc., Muscatine, engrs.

**Ia., LaPorte City**—Election Feb. 5, to vote on $100,000 bonds, for constructing municipal light and power plant.

**Ia., Waukon** — Municipality plans electric power plant, probably diesel. Contractor to finance and be paid from earnings of plant.

**Kan., Burlington** — City plans light plant, $145,000. Hearing in April by Supreme Court on private utility injunction. E. T. Archer & Co., 609 New England Bldg., Kansas City, Mo., engrs.

**Mass., Boston**—City, P. Buildings Dpt., 802 City Hall Annex, filed bill in State House of Representatives to borrow $40,000,000 for electric light plant. Maturity indefinite. Engineer not appointed.

**Mass., Fitchburg**—City, R. E. Greenwood, mayor, City Hall, plans municipal light plant. Maturity indefinite. Engineer not appointed.

**Miss., Jackson** — City defeated $1,500,000 bond issue for power plant and distribution system. Project abandoned.

**Mo., Anderson**—City voted $55,000, for constructing hydro-electric dam and power plant. P.W.A. project. A. C. Moore, engr., Box 305, Joplin, prepared plans for same.

**Neb., Ord**—City plans remodeling power plant and installing new diesel engines. Black & Veatch, 700 Mutual Bldg., Kansas City, Mo., engrs.

**N. J., Overbrook**—Overbrook Hospital plans by Runyon & Carey, 31 Fulton St., Newark, electric power plant addition at hospital, incl. purchase of two 1,000 kw. steam turbo-generators. $125,000. P.W.A. project.

**N. Y., Genesee**—Bd. Village Trustees plans municipal light and power plant. $125,000. L. C. Reynolds, 387 Castle St., Geneva, engr.

**N. Y., Ogdensburg**—City, R. J. Morisette, mayor, plans municipal light and power plant. Maturity soon.

**N. C., Charlotte**—Hudson Silk Knitting Co., c/o M. E. Pierson, 712 North Brevard St., plans hosiery plant, incl. power plant on 8 acre site, near here. Site purchased. To exceed $300,000.

**O., Bellevue**—City retained archt. and engr. R. Husselman, Hippodrome Bldg., Cleveland, to prepare survey for municipal light plant. $200,000.

**O., Cleveland** — City plans application to P.W.A. for $3,000,000 loan to finance construction municipal electric light plant expansion, incl. power plant addition, new turbine and boiler room buildings, $450,000; turbine boiler and foundations, $33,000; 20,000 kw. turbo-generator, $350,000; condensers and equipment, $80,000; circulating water connections, $25,000; switchboard and equipment, $105,000; relocate reactors and transformers, $110,000; boilers, superheaters, economizers, air preheaters, and fuel burning equipment, $440,000; coal bunkers, trestle extension, conveyors, etc., $60,000; boiler feed pumps, chimney and auxiliary equipment, $32,000; piping, gages and meters, $125,000; engineering and contingencies (10%), $181,000; transmission system extensions, Union Ave. sub-station, $144,000; Euclid-E. 105th Dist. sub-station, $150,000; Collinwood sub-station enlargement, $70,000; Easterly sewage disposal plant service, $38,000; Western Ave. sub-station enlargement, $55,000; East 79th St. sub-station enlargement, $27,500; Mall lighting, $20,000; distribution extensions, conduits, manholes, underground lines, poles, fixtures, overhead lines, transformers, service connections and meters for approximately 5,040 new consumers, $504,000.

**O., East Palestine**—City, H. Lemle, dir. P. Serv., retained F. N. Straus, engr. and archt., 2613 Queenston Rd., Cleveland, to prepare survey for light plant improvements.

**O., Harrison**—City reports in progress for power plant and distributing system. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., Kansas City, Mo., engrs.

**O., Niles**—City reports in progress power plant. Burns & McDonnell Eng. Co., 107 West Linwood Blvd., Kansas City, Mo., engrs.

**Pa., Phila.**—Philadelphia Electric Co., 1000 Chestnut St., Phila., budget has provided $8,800,000 for additions, extensions and betterments to electric power plants, distribution system in Phila. and vicinity.

**Pa., Turtle Creek**—Borough, J. G. McClintock, chn. Lighting Com., authorized to obtain sketches for municipal light and power plant. $100,000 or more. Maturity indefinite.

**R. I., Coventry**—Interlaken Mills, 1101 Turks Head Bldg., Providence, plans power plant addition and alterations. To exceed $28,500. John A. Stevens, Inc., 16 Shattuck St., Lowell, Mass., consult. engrs.

**R. I., Providence**—City, S. F. Nolan, comr. P. Wks., City Hall, making plans municipal power plant. S. F. Nolan, engr. Maturity indefinite. Site not selected.

**Tenn., Chattanooga**—Tennessee Electric Power Co. plans expending $1,300,000 during 1935 for improvements to distribution lines, transmission lines and power plants.

**Tex., Margaret**—Place River Development Assn., c/o E. R. Brown, pres., Electra, revised report by J. E. Ward, Wichita Falls, Engr., building rein.-con. power dam across Pease River, near here (Foard Co.). $3,360,000. P.W.A. application filed.

**Vt., Enosburg Falls**—Town, plans hydro-electric plant. Maturity indefinite. A. L. Nelson, 31 St. James Ave., Boston, Mass., engr.

**Wash., Seattle**—City plans waterworks betterment program, incl. new dam and hydro-electric plant for up-river pumping station $623,573, south side pumping plant with connecting mains $288,115, replacing old mains $445,000. Total expenditure $1,356,689. City proposes to borrow money from Federal Govt. without interest and will make repayment at the rate of 5% a year.

**Wyo., Yellowstone Park** — National Park Service, 409 Underwood Bldg., San Francisco, Calif., plans improving and expanding hydro-electric plant, at Mammouth Hot Springs, incl. 2 new units in present plant and new hydro-electric plant on Panther and Indian Creeks, to generate 800 kw. $237,000 allotted by P.W.A.

**Ont., Kitchener** — Ontario Hydro-Electric Comn., T. S. Lyon, chn., Toronto, preparing plans constructing experimental plant. $100,000.

**Ont., Schrieber**—E. J. Sheehan, mayor, soon takes bids municipal lighting plant. $25,000.

**Armenia**—Electric Trust, Soviet Govt., Moscow, or c/o Amtorg Trading Corp., 261 5th Ave., New York, constructing Sevan Hydro-Electric Cascade, consisting of 9 hydro-electric projects on Lake Sevan and Zangi River, to irrigate 80,000 hectores and supply power for chemical and rubber industries, construction to begin this year, by day labor.

**India**—Government of Madras, bids in March, for hydro development at Mettur, $6,000,000.

Volume 79 Number 3

# POWER

MASON BRITTON, *Vice-president* — N. O. WYNKOOP, *Manager*

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# *No Shut-Downs with*
# DE LAVAL WORM GEARS

175 gears running continuously day and night for 5 to 7 years, exposed to the grit, shock loads and lack of attention of cement mill operation is surely a rigorous test of reliability, but read what Supt. Reichenbach says:

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GENERAL OFFICES NAZARETH, PA.
PORTLAND NAZARETH CEMENT
SALES OFFICES
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NAZARETH, PA. June 12, 1934

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Yours very truly,
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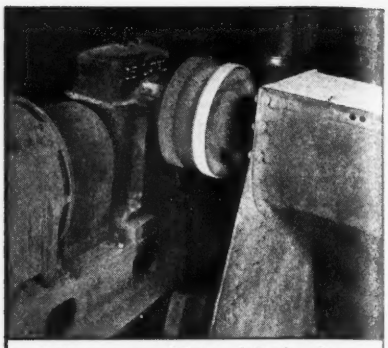
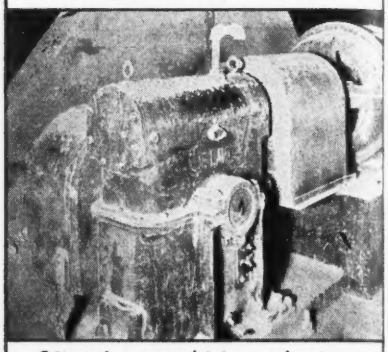
HAR:FM

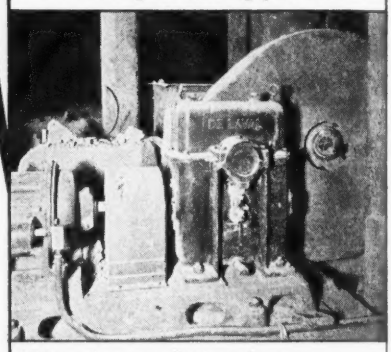
Your speed transformer requirements may be even more exacting than those at Nazareth, but we are confident that we can satisfy you.



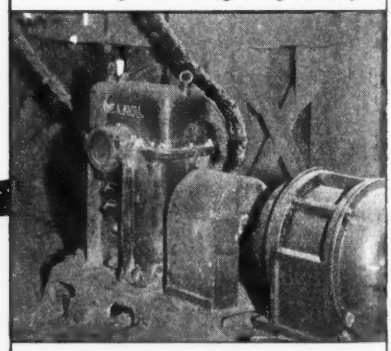
Worm gear driving kiln feeder



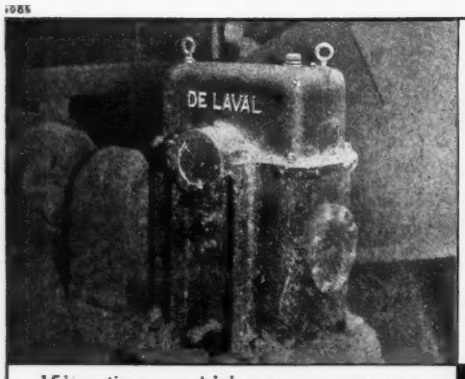
3⅝ ratio gear driving pulverizer



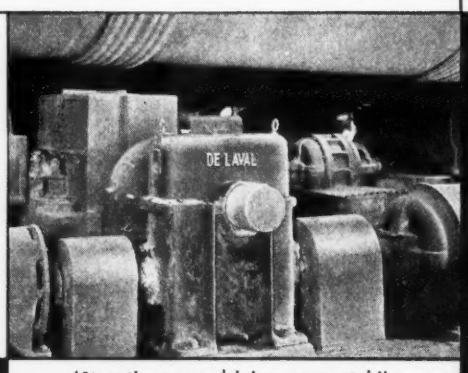
15½ ratio gear driving drag conveyor



9¾ ratio gear operating elevator; notice overhung sprocket




15½ ratio gear driving screw conveyor




4⅝ ratio gear driving cement kiln

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